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Crop Production.

State of New York — Department of Agriculture

EIGHTEENTH ANNUAL REPORT

OF THE

BOARD OF CONTROL

OF THE

NEW YORK

Agricultural Experiment Station

(GENEVA, ONTARIO COUNTY),

FOR THE YEAR 1899,

WITH REPORTS OF DIRECTOR AND OTHER OFFICERS.

TRANSMITTED TO THE LEGISLATURE FEBRUARY 21, 1900.

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STATE OF NEW YORK.

No. 83.

IN ASSEMBLY,

FEBRUARY 21, 1900.

EIGHTEENTH ANNUAL REPORT

OF THE

Board of Control of the New York Agricultural Experiment Station.

STATE OF NEW YORK:

DEPARTMENT OF AGRICULTURE,

ALBANY, *Feb.* 21, 1900.

To the Assembly of the State of New York:

I have the honor to herewith submit the Eighteenth Annual Report of the Director and Board of Managers of the New York Agricultural Experiment Station at Geneva, N. Y., in pursuance of the provisions of the Agricultural Law.

I am, respectfully yours,

CHARLES A. WIETING,

Commissioner of Agriculture.

1899.

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‡CHARLES P. CLOSE, M. S.,
Assistant Horticulturists.
FRANK E. NEWTON,
JENNIE TERWILLIGER,
Clerks and Stenographers.
ADIN H. HORTON, *Computer.*

Address all correspondence, not to individual members of the staff, but to the NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

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* Connected with Fertilizer Control.
† Connected with Second Judicial Department Branch Station.
‡ Resigned September 19, 1899.

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Eighteenth Annual Report

OF THE

Board of Control of the New York Agricultural Experiment Station.

TREASURER'S REPORT.

Geneva, N. Y., *October* 1, 1899.

To the Board of Control of the New York Agricultural Experiment Station:

As Treasurer of the Board of Control, I respectfully submit the following report for the fiscal year ending September 30, 1899.

Maintenance Account.

Receipts.

1898.			
Oct.	1.	To balance on hand	$591 77
		To amount received for produce sold .	2,105 20
		To amount received from Comptroller,	60,000 00
			$62,696 97

Expenditures.

By building and repairs	$1,359 97
By chemical supplies	892 27
By contingent expenses	649 11
By feeding stuffs	945 72
By fertilizers	26 08

By freight and express	$494 21
By furniture and fixtures	1,177 46
By heat, light and water	2,554 06
By labor	12,695 54
By library	676 54
By live stock	434 00
By postage and stationery	1,170 30
By publications	2,640 81
By salaries	21,232 88
By scientific apparatus	961 05
By seeds, plants and sundry supplies,	1,974 69
By tools, implements and machinery	739 63
By traveling expenses	1,232 88
By balance	10,839 77
	$62,696 97

EXPENSE OF BULLETINS AND ENFORCING PROVISIONS OF CHAPTER 955, LAWS OF 1896.

Receipts.

1898.			
Oct.	1.	To balance on hand	$1,954 99
		To amount received from Comptroller,	10,000 00
			$11,954 99

Expenditures.

By chemical supplies	$940 28
By contingent expenses	4 30
By freight and express	36 89
By furniture and fixtures	1 40
By heat, light and water	522 98
By postage and stationery	13 71
By publications	2,459 47
By salaries	5,629 18

By seeds, plants and sundry supplies..	$3 35
By traveling expenses	1,023 12
By balance	1,320 31
	$11,954 99

SECOND JUDICIAL DEPARTMENT, CHAPTER 675, LAWS 1894.

Receipts.

1898.			
Oct.	1.	To balance on hand	$46 34
		To amount received from Comptroller,	7,466 80
			$7,513 14

Expenditures.

By chemical supplies	$10 09
By contingent expenses	15 13
By fertilizers	216 80
By freight and express	119 04
By furniture and fixtures	95
By heat, light and water	34 52
By labor	815 13
By library	5 85
By postage and stationery	8 33
By publications	565 90
By salaries	2,872 08
By scientific apparatus	74 25
By seeds, plants and sundry supplies..	482 82
By tools, implements and machinery..	101 92
By traveling expenses	852 99
By rent (land)	1,291 00
By balance	46 34
	$7,513 14

SPECIAL APPROPRIATION FOR BIOLOGICAL AND DAIRY BUILDING, CHAPTER 315, LAWS 1897.

Receipts.

1898.		
Oct.	1. To amount received from Comptroller,	$8,994,37

Expenditures.

By construction	$6,186 32
By equipment	2,808 05
	$8,994 37

SPECIAL APPROPRIATION FOR BUILDINGS AND REPAIRS.

Receipts.

1898.		
Oct.	1. To amount received from Comptroller,	$885 09

Expenditures.

By buildings and repairs	$885 09

PARIS GREEN LAW, CHAPTER 113, LAWS 1898.

Receipts.

1898.		
Oct.	1. To amount received from Comptroller,	$123 90

Expenditures.

By contingent expenses	$0 20
By freight and express	2 15
By postage and stationery	25
By salaries	45 00
By seeds, plants and sundry supplies..	4 16
By traveling expenses	72 14
	$123 90

I have remitted to the State Treasurer $235.21 for produce sold.

All expenditures are supported by vouchers approved by the auditing committee of the Board of Control, and have been furnished the Comptroller of the State of New York.

United States Appropriation Under Act of Congress, Approved March 2, 1887.

To receipts from the Treasurer of United States for fiscal year ending June 30, 1899	$1,500 00

Expenditures.

By salaries	$1,500 00

William O'Hanlon,
Treasurer.

DIRECTOR'S REPORT.*

To the Honorable Board of Control of the New York Agricultural Experiment Station:

Gentlemen.— I have the honor to present herewith the report of the progress and work of the New York Agricultural Experiment Station for the year 1899.

The year 1898 was characterized by large and important additions to the building and apparatus equipment, but the past year has been occupied chiefly with the quiet study of certain important problems.

It is a pleasure to report to you that without exception the members of the various departments of the Station are giving to their work a very gratifying measure of diligence and efficiency. The pursuit of knowledge with the attendant vicissitudes of original observation and research requires enthusiasm and courage, especially when the long delay of results may cause public criticism; and he who keeps on his way in a spirit of loyalty to truth and with a proper sense of responsibility for his utterance is deserving of his full meed of praise. I believe the members of your Station staff recognize the high standard to which they should attain and are striving to reach it.

THE STATION STAFF.

After more than three years of efficient service at the Station as Assistant Horticulturist, Mr. C. P. Close resigned his position in September last to accept the chair of Botany and Horticulture in the Utah Agricultural College. A successor to Mr. Close has not yet been selected.

* Reprint of Bulletin No. 168.

Mr. Lowe was granted a six months' leave of absence and is now pursuing special zoological studies at the University of Chicago.

STUDENT ASSISTANTS.

So far in the history of American experiment stations the number of well trained young men available from which to choose investigators has been altogether too limited, especially in biological lines. Graduates of our colleges when fresh from laboratory instruction seldom have much facility in making a logical attack upon a difficult problem affecting practice until after they have been for a time in the atmosphere of real research. It was felt that it would be possible to associate with our work young men having taste for investigation in experiment station lines, in such a way as to derive mutual benefit. In view of this conclusion and in accordance with authority granted me by you, a circular letter containing the following statements was addressed to a large number of the land grant colleges:

"By authority of the Board of Control of this Station, we are prepared to admit to our laboratories three student assistants; one in each of the departments of botany (plant pathology), bacteriology (dairy), and entomology. In order to be eligible to these positions, candidates must be graduates of a four years' course in science, preferably at a land grant college where the sciences are taught with especial reference to their bearing upon the art of agriculture. It is essential, moreover, that such candidates shall have pursued studies specially fitting them to undertake work in one of these departments and that they shall have shown such proficiency and enthusiasm in special directions as will warrant their choosing one of these lines of study and investigation for a life work.

"As their main work, it is proposed, under the guidance of the heads of departments, to associate these assistants with one or more important subjects of investigation, with the understanding that they shall devote a minor proportion of each day, perhaps two hours, to the care of the laboratories, preparation of materials and other routine duties. They must be prepared to enter immediately, under proper direction, upon a study of one or more problems, without spending a considerable period of time in acquiring the necessary preparatory knowledge and skill of a fundamental character. For instance, the student assistant in bacteriology should be familiar in a practical way with the technics of making culture.

"Full credit will be given in our publications for work accomplished.

"It is hoped that the observation and experience gained by such close association with the actual research work of an experiment station will constitute a valuable training for those who are ambitious to connect themselves with experiment stations as investigators.

"The selection of these assistants will properly and necessarily be based upon their records as students and upon such knowledge of their personality as may be gained in various ways.

"It is expected that they will remain at the Station not less than one year. Board, rooms and laboratory materials will be furnished free of charge, no other compensation being offered."

From the applicants for these positions, two were selected, Mr. L. A. Rogers, as student assistant in Bacteriology, and Mr. E. D. Merrill, as student assistant in Botany. Both men graduated from the University of Maine and had received some post-graduate training. Mr. Rogers had spent a year at the University of Wisconsin, giving special attention to dairy bacteriology, and Mr. Merrill had had a year's experience as instructor in the department of natural history at his alma mater. The former entered upon his work in June, but the latter, on the day in which he reported to us for duty, received an offer of a position in the U. S. Department of Agriculture which he felt that it was for his interest to accept. Since that time Mr. F. M. Rolfs, a graduate of the Iowa Agricultural College, and a teacher of considerable experience, became an applicant for the position of student assistant in Botany, received the appointment and entered upon his duties on December 21st.

As there was no application for the position in Entomology, it remains unfilled.

NEEDED CHANGES AND ADDITIONS.

The time has come when it is necessary to provide larger and more efficient accommodations for the various administrative offices and the library. These are now mostly located in a building the upper floors of which are occupied by the Director as a home, an arrangement which is unsatisfactory in every respect. There is at present only one general office in which are the desks of the Director and two clerks, a combination which

results in great inconvenience. The mailing department is temporarily located on the second floor of the Chemical Laboratory, rendering it necessary to carry up and down stairs many tons of mailing matter yearly. All of the administration work of the Station and the library should be newly installed under one roof, for reasons of space as well as economy of labor.

Two general ways of accomplishing this have been considered: One proposition is to erect a new administration and library building and convert the house where the offices now are wholly to domestic purposes; the alternative is to build a new director's house and turn over the mansion house wholly to office and library uses. The arguments in favor of the former course are that the administration and library building should correspond in dignity and attractiveness to the other structures on the Station grounds, and besides new construction would give an opportunity to make the offices models of convenience and efficiency, without being hampered by the limitations of an existing structure. This is the more costly plan, involving an outlay of not far from $32,000. On the other hand a new house would place the director on a more comfortable and economical living basis than would be the case if the somewhat overlarge house in which he now lives were given over wholly to his occupancy, while this building is probably large enough for the administrative offices and library, though if reconstructed for these purposes it would fail, as has been stated, of the dignity and convenience of a new building. The probable cost of the second proposed plan would be somewhere from $16,000 to $19,000. The argument of less cost is with the second proposition.

It seems proper to state in this connection that the water supply of the Station is in some respects very unsatisfactory. It is furnished by the city at an annual cost of $501, and if the pressure on the hydrants was such as to insure protection against fire, and at the same time provide a constant and uniform flow of water in the laboratories, there might be no good reason for con-

sidering a change. The conditions which prevail are the reverse of these, however, especially during the summer. Whenever hydrant pressure is available it averages less than twenty pounds, and at times it is a minus quantity, a condition which often causes great inconvenience in laboratory work and especially in running the refrigerating machine, besides being practically useless for fire purposes. It seems desirable for your board to consider whether any improvement in our water supply is possible.

INSPECTION OF FERTILIZERS AND FEEDING STUFFS.

The Legislature of 1899 made two enactments which both modified and enlarged the inspection work of the Station.

The Fertilizer Law was so amended as to require the payment of a license fee of $20 on each brand of commercial fertilizers sold or offered for sale in the State, thus bringing New York into line with the other twenty-eight states in which fertilizer laws exist. The money received from such fees is to be devoted to paying the expenses of inspection, which renders unnecessary the appropriation heretofore made by the state for this purpose. In 1898 the number of brands of fertilizers registered at the Station by manufacturers was 2,226, and it now seems probable that in 1899 it will fall to less than 500. This decrease is not caused wholly by the imposition of license fees, but without question is due in part to the formation of a fertilizer combination or trust. Some have thought that the advance in prices is also the result of the exaction of license fees, but this surely cannot be so, because the total annual expense of such fees to the fertilizer industry will not exceed an average of six cents per ton on the quantity of goods sold.

Other conditions are responsible for the increased cost to the farmer of his commercial plant food.

A new law, quite similar in its provisions and operation to the amended fertilizer law, the author of which is the Hon. D. P. Witter, was also enacted for the control and inspection of con-

centrated commercial feeding stuffs. As with fertilizers, manufacturers of feeding stuffs must register at the Station a guaranteed composition and pay the annual license fee on each brand sold or offered for sale, the proceeds thus derived to be used in the yearly collection and analysis of samples by the Station and the printing of results. It now seems that the brands registered will not exceed one hundred, so that the revenue produced by this law will not be large. Attention is called to the fact that in the case of both laws, the license fees are paid into the state treasury and the amounts of money thus received by the state only become available for their legitimate uses after appropriation by the legislature.

THE MAILING LIST.

The present status of the mailing list is as follows:

Popular Bulletin List.

Residents of New York	30,337
" " other states	992
Newspapers	744
Experiment Stations and their staffs	778
Miscellaneous	131
Total	32,982

Complete Bulletin List.

Experiment Stations and their staffs	778
Libraries, scientists, etc.	257
Foreign list	55
Individuals	902
Miscellaneous	131
Total	2,123

The above figures show a small increase in the popular bulletin list for residents of New York. During the past year this list

has been revised, resulting in taking off the names (not less than 2,000) of those who had died or changed their place of residence. There has been a steady registering of new names, however. This growth is normal and not forced, coming as it does almost wholly from individuals who personally ask to receive the bulletins of the station.

THE STATION LIBRARY.

A good library is a most necessary part of an experiment station equipment. Research can neither be entered upon safely nor its results discussed intelligently unless the investigator has access to the records of what has been learned previously concerning the subjects under consideration. Access to current literature and particularly to the journals which are the organs of research, is especially important in this connection.

The library of this Station has developed rapidly during the past two years, but it is still small and in some respects quite insufficient for our needs. A fairly large number of journals is received, but complete sets of them should be obtained as rapidly as possible. The present number of bound volumes and pamphlets in the library is approximately five thousand.

A list of the papers and journals obtained by subscription and donated to us by exchange or otherwise is appended to this report.

THE STATION PUBLICATIONS.

The public is not unnaturally inclined to measure the usefulness of an experiment station by the quantity of literature which it publishes. If this standard is applied to the New York State Station, the year 1899 will appear to be less profitable than some which have preceded. As a matter of fact, however, there probably has not been a period in the history of the Station when so much hard study has been applied to so large a number of problems as has been the case during the past twelve months.

The number of pages of printed matter which a station issues has no necessary relation to the actual magnitude of the effort of

investigation. A bulletin of one hundred pages, which is merely a compilation of existing knowledge, may be begun and finished within the limits of a few weeks, whereas the data derived from one or more years of laborious observation may be summarized for public use on ten pages.

Two facts are likely to restrict the literature emanating from this Station to a less quantity than may seem to some to be consistent with its equipment.

(1) It is deemed to be a proper policy on the part of the Station to issue comparatively few bulletins of compilation of a purely informational character. More or less discussion of existing knowledge is necessary in order to give to the results of research a proper setting and illumination, but it is certainly not the function of the Station, now that its existence and purposes are well understood, to engage in the work of popular instruction. To do this would be to encroach upon the province of the school and of current literature. It might seem justifiable for this Station to digest and summarize for the use of New York farmers the knowledge gained by the stations in other states, were it not for the fact that the U. S. Department of Agriculture is doing this admirably through the Office of Experiment Stations. It is conceded that when emergencies arise or when an entirely new situation faces the agricultural public, like the sudden inroad of devastating insects or the establishment of the sugar beet industry, farmers are justified in looking to the Station for information of a general character. This is a different matter, however, from writing general treatises on a great variety of subjects. This institution, in my judgment, will do well to restrict its efforts quite closely to the work of experimental research.

(2) It has become imperative that this Station attack some of the more difficult scientific problems relating to agriculture. Many of the "easy questions" have been asked and answered and for this reason, and also because the "hard answers" are the

ones we most need to know, we should begin to probe more deeply and laboriously beneath the surface of things. There is, moreover, a pronounced tendency now evident in many quarters to withhold the publication of conclusions until they are abundantly justified by data, a most healthy and encouraging symptom in experiment station activity. The members of this Station believe in trying to enter upon the policy thus outlined and it is to be hoped that in so doing they will have the sympathy and loyal support of New York farmers.

It should be remembered that this policy means the publication of fewer bulletins than might otherwise be issued if the practice of compilation and profuse writing were adopted.

THE WORK OF THE STATION DURING 1899.

On subsequent pages there may be found summaries of the work carried on during the year 1899 by the various departments of the Station. These include a brief review of facts and conclusions contained in the year's bulletins as well as a statement of the nature and bearing of experiments and investigations, the data from which are not yet sufficiently complete and concerning which nothing has yet been published. It so happens that just now the unfinished work is large. It embraces several investigations in plant nutrition, animal nutrition, cheese curing, horticulture, bacteriology and plant pathology:

The availability of certain insoluble phosphates to several varieties of plants.

The relative importance of potash and soda in plant nutrition.

The effect of fineness upon the availability of crude phosphates.

The plant food needs of fruits and the effect of certain plant food elements upon their quality.

Relative economy of different systems of feeding crops.

A study of apple cider and vinegar.

The source of milk fat and observation on the use of food by milch cows.

The chemistry and bacteriology of cheese curing.

Study of cheese curing troubles such as rust, and sweet and bitter flavors.

Conditions of cheese curing.

The prevention of onion smut.

The prevention of asparagus rust.

A study of black knot.

The irrigation of small fruits.

Chestnut growing.

CHEMICAL DEPARTMENT.

(1) *Fertilizer inspection.*—The fertilizer trade has continued to present during 1899 its usual grotesque features. One hundred and ninety manufacturers, sixty-seven of whom are located outside of New York, registered at the Station 2,268 different brands. For various reasons the number of brands sold in the State is much short of registration. This burdensome and unsatisfactory state of affairs will doubtless end with 1899, as the number of brands registered is likely to drop to 500 or less, for reasons already explained.

(2) *Paris green and insecticide supervision.*— Twenty-five samples of Paris green were secured and analyzed. Twenty different manufacturers represented. Arsenious oxide found in Paris green varied from 55.34 to 60.16 per ct., indicating a good degree of commercial purity.

(3) *Plant nutrition.*— Work is being continued in investigation relating to the plant-food needs of fruits and the effect of certain plant-food elements upon the quality of fruits. Results are being held for additional data before publication.

(4) *Composition of cider and vinegar.*— This work has been continued two years and valuable results are being secured, but another year's data are desired before publishing the results of investigation.

(5) *Cheese work.*— Data for publication will probably be ob-

tained in addition to those on hand during the coming year. Chemical work has been directed in two lines:

(a) Studying the influence of moisture and temperature upon the composition of cheese, working with the temperatures 55°, 60°, 65° and 70° F.

(b) Studying the chemical compounds formed in cheese by the breaking down of milk casein.

HORTICULTURAL DEPARTMENT.

The fertilization of self-sterile grapes.— It has been shown in Bulletin 157 and other prior publications of this Station, that certain kinds of American grapes are either self-sterile or very imperfectly self-fertile. When self-pollinated the former bear no fruit and the latter produce very imperfectly formed clusters or usually none at all. In considering the practical bearing of these discoveries upon the selection of varieties for planting and the advantageous arrangement of them in vineyards for securing well filled fruit clusters, the question arose whether any other variety which blooms at the same time with the one which is to be fertilized will perform the necessary cross fertilizing successfully or whether some kinds of grapes are better fertilizers than others. Scarcely any definite information on this subject could be found. The matter being one of obvious practical importance to viticulturists, some investigations concerning it were begun in 1899. Very marked results have already been secured, indicating that a variety which is more or less incapable of fertilizing itself generally fails in the fertilizing of other self-sterile varieties, while on the other hand the self-fertile varieties have usually been successful in fertilizing the self-sterile sorts upon which they have been tried. Further investigation is necessary to determine whether any grape may be more successful in fertilizing some varieties than others. Various other tests need to be made before a final report is given stating definitely the conclusions which may be drawn concerning the question under investigation.

The treatment of diseases and insects is of perennial interest to fruit growers. A bulletin has been prepared on this subject by the collaboration of the Horticulturist, the Botanist and the Entomologist for the purpose of presenting up-to-date directions for fighting these enemies of the fruit grower and showing the particular instances in which various diseases and insects may be combated with one general treatment. The preparation of spray mixtures and the apparatus for applying them are treated in Bulletin 121, prepared by Mr. Paddock. This has been supplemented by publishing an appendix which treats of recently improved apparatus and gives formulae for the preparation of various spraying mixtures.

Thinning apples.— Experiments have been in progress for four years for the purpose of gaining definite information concerning the effect which thinning the fruit of apple trees may have on the remaining crop and whether the practice if followed systematically year after year tends to secure greater regularity in bearing or increased yield in succeeding seasons.

The results show that with certain varieties the size and color of the fruit are generally improved where thorough and timely thinning is done and the percentage of the higher grades of fruit is increased, although the total yield of marketable fruit is often lessened. It appears that under certain circumstances, and especially with certain varieties, the thinning of apples in commercial orchards would be profitable.

With mature trees which have come into full bearing and which are properly fertilized, pruned, sprayed and generally well cared for, it is doubtful whether thinning the fruit in any one season will materially increase the yield in succeeding seasons. It should be borne in mind that young trees which have not come into full bearing may be seriously impaired in vigor and in subsequent fruit production by being allowed to mature too heavy crops.

It appears that, with the exception noted, the principal source

of profit from thinning fruit in orchards which are well cared for is to be looked for chiefly in preventing the breaking of overloaded limbs and in the increased market value of the fruit of the current season.

Thinning, to be most effective, should be done early in the season — at the time Baldwins and Greenings are from three-fourths of an inch to an inch in diameter. In New York State it should be completed in June.

Thinning stone fruits.— Experiments in thinning apricots, plums and peaches have been in progress three seasons. With these fruits as with apples the effect of thinning is not always as pronounced the following year as had been expected. In some cases there appeared to be real permanent advantage and an increased yield in succeeding seasons, and again the effect, if any, on the crop of the following year, was in some cases obscured by causes not understood and no advantage from the previous year's thinning of the fruit could be seen. In some cases trees which were heavily loaded and not thinned gave even greater yields the following season than were obtained from corresponding trees on which the fruit had been severely thinned.

Early and severe thinning in general increased the percentage of the higher grades of fruit. Where the fruit grower can obtain correspondingly better prices for fancy fruit the thinning may doubtless be made profitable with selected varieties of peaches and apricots and in some cases with plums also.

Chemical analyses of fruits which were picked at different stages were made in the chemical department which showed that the amount of potash in the fruit of one variety of peach increased 493 per ct. from June 24 to July 21. The nitrogen increased 240 per ct. and the phosphoric acid 327 per ct. in the same period. The amount of potash in the fruit of a certain variety of plum increased in the same period 296 per ct., the nitrogen 222 per ct. and the phosphoric acid 156 per ct. This indicates how rapidly the fruits take up plant food in the very

early stages of their growth and emphasizes the importance of doing the thinning very early in the season.

Fertilizers for forcing lettuce.— Complete commercial fertilizers which differ from each other only in material from which the supply of nitrogen is secured are being tried both alone and in combination with varying proportions of stable manure, on soils for forcing lettuce. Each formula is tried with head lettuce and with loose lettuce, both on medium heavy clay loam and on very light sandy loam. The object of this work is to throw some light on the question as to whether, in the forcing of lettuce, commercial fertilizers may be profitably substituted either wholly or in part for stable manure. It is desirable that the results which have been thus far obtained should receive further confirmation before being published.

Treatment for gooseberry mildew.— Because of the destructive character of gooseberry mildew and the economic importance of this disease in all parts of America where gooseberries are cultivated, experiments have been conducted for the purpose of treatin the disease on a commercial scale. Potassium sulphide has been compared with other fungicides for this purpose and very early treatments have been compared with later treatments so as to learn if possible just when to spray and what to spray with in order to hold the mildew in check most successfully. This particular line of investigation has been in progress since 1897. The results, as set forth in Bulletin 161, show that the use of potassium sulphide has been followed with better success than the use of Bordeaux mixture, lysol or formalin. Bordeaux mixture proved comparatively useless; formalin was somewhat more effective and lysol gave promising results, ranking next to the potassium sulphide. Very early spraying generally gave better results than when the first treatment was made medium early or late. Winter treatment was tested only one season. It did not give sufficient advantage to justify the expense of making it.

Apple canker.— A disease of apple tree limbs has done and is

doing an immense amount of damage to the orchards of New York as well as in many other states. The disease is not new but the injuries resulting from its attack have been thought to be due entirely to the sun-scald, so it has escaped the notice of workers in this line.

The investigation of this disease was undertaken in the spring of 1898 and was continued through the present season. It has been proven that the cankers are produced by the attack of a fungus known as *Sphaeropsis malorum* Pk., the same that produces the black rot of apples, pears and quinces. The experiments also indicate that the fungus occurs on a number of other plants.

Experiments in treating the disease are not yet complete, but it is known that in a majority of instances orchards that have been well sprayed with Bordeaux mixture for a number of years and otherwise well taken care of are much freer from canker than orchards that have not received such treatment.

As a preventive measure we feel warranted in recommending that the orchards be put in the best growing condition and then as a further preventive that they be sprayed thoroughly with Bordeaux mixture, spraying the limbs as well as the foliage and fruit; the spraying to be made at the time the trees are ordinarily sprayed for apple scab, supplemented by an earlier one given about the time the leaf buds begin to unfold.

DEPARTMENT OF BOTANY.

Leaf-scorch of sugar beet, cherry, cauliflower and maple.— A peculiar disease of sugar beets occurring to a destructive extent in some fields in Yates and Ontario counties has been determined to have been caused by weather conditions. In early August the foliage was suddenly scorched by excessively dry, hot weather. Cherries and hard maples in the vicinity of Geneva and cauliflower on Long Island have suffered from the same cause.

Fruit-disease survey of the Hudson Valley.— A thorough survey has been made of the fruit diseases occurring in the Hudson

Valley. On account of the unusually dry season fruits generally have suffered less from disease than for several years past. Peach leaf-curl, so destructive in 1898, has been almost wholly absent. Such common destructive diseases as apple scab, pear scab, pear leaf-spot and plum leaf-spot have been injuriously abundant only in a few localities. The black rot of grapes and the fruit-rot of plums and cherries have been much less destructive than usual. The most important fact brought out by this survey is the discovery that there exists throughout the entire Hudson Valley below Albany a destructive cane blight of currants caused by a sterile fungus about which but little is known.

Miscellaneous studies on plant diseases.— In 1898, a serious rot of onions occurred in Orange county. It has been determined that this rot was caused by bacteria working in the presence of water. The prompt removal of surface water from the onion fields is probably the best that can be done to prevent the rot.

Dodder has been found on greenhouse cucumbers and a powdery mildew on field cucumbers.

The brown sunken spots on Baldwin apples have been shown to be of non-parasitic origin.

A new fungus leaf-spot disease of carnations has been discovered.

Unfinished work.— Considerable work has been done upon the stem-rot diseases of the carnation, and an investigation of the black knot disease of plums and cherries commenced.

DEPARTMENT OF BACTERIOLOGY.

Pasteurization for butter making.— A fundamental investigation of this problem has been begun in connection with the Dairy Department, the first step being a study of the effect of the various temperatures to which milk can be exposed in the "continuous" machines. A momentary exposure at 158° F. was not found satisfactory; 176° F. is much better and in many cases 185° F. is desirable. When the most acceptable temperature is

decided upon the subject of pasteurized *vs.* unpasteurized butter will be taken up.

Cheese faults.— Rusty spot in Cheddar has received considerable attention. A germ has been isolated which on being added to a vat of milk produced rusty spots in the resulting cheese. Work will be continued with a hope of finding the way in which the trouble gains entrance to the factory as well as the best method of removing it.

Work has also been done on *sweet* or *fruity* flavor but owing to the obscure nature of the trouble little headway has been made. *Bitter* flavor in Neufchatel has been reported and the trouble found due to the presence of certain acid forming bacteria. This investigation is still in progress.

Cheese ripening.— Several experiments have been carried out, alone, and in conjunction with the Department of Chemistry. The attempt has been made to exclude the action of germs in order that the activity of the enzyme naturally present in the milk and cheese might be more carefully studied.

Black rot of cabbage and cauliflower.— In collaboration with the Department of Botany field experiments on the treatment of the black rot of cabbage and cauliflower have been conducted at Phelps and on Long Island; but owing to the unusually dry season the disease was not prevalent and consequently few results were obtained. These experiments will be repeated next season.

ANIMAL INDUSTRY.

Animal food in poultry feeding.— It was found in a number of feeding experiments with chicks, ducklings and laying hens that rations containing animal food gave almost invariably better results than did those consisting entirely or very largely of vegetable food. For convenience "animal meal" was made the principal animal food. Many grain foods were used; but when rations were so arranged that the proportion of protein was alike for two rations the one with the animal food contained generally more fat and always a much larger percentage of mineral matter.

The first series of experiments did not definitely indicate the cause for the superiority of the one ration. It appeared that the more favorable results when animal food was fed might be due either to the more efficient forms of the nitrogen compounds or with the rapidly growing young birds and the laying hens to the much larger proportion of ash consisting largely of phosphates.

Subsequent experiments have shown that while ducklings require a certain amount of animal food, hens and chicks are able to do well on wholly vegetable food, supplemented by ash rich in phosphates. In these experiments, rations of vegetable food, to which bone ash was added to make up the assumed deficiency of ash, in growing chicks gave identical results with those from rations containing animal food. With laying hens the rations were equally efficient for most of the time but good results were not sustained quite so long by the vegetable food ration. The addition of bone ash did not, however, enable ducklings to make as good use of a ration wholly of vegetable foods; such a ration being decidedly less efficient than one containing animal food.

BULLETINS PUBLISHED IN 1899.

No. 158 — May.— Combating the striped beetle on cucumbers. F. A. Sirrine. Pages 32, plates 2.

No. 159 — October.— The forest tent caterpillar. V. H. Lowe. Pages 30, plates 6.

No. 160 — October.— Report of analyses of commercial fertilizers for the spring of 1899. L. L. Van Slyke. Pages 90.

No. 161 — November.— Treatment for gooseberry mildew. C. P. Close. Pages 12, plates 2, diag. 1.

No. 162 — November.— Leaf scorch of the sugar beet, cherry, cauliflower and maple. F. C. Stewart. Pages 14, plates 6.

No. 163 — December.— The New York apple-tree canker. Wendell Paddock. Pages 28, plates 6.

No. 164 — December.— Notes on various plant diseases. (A bacterial rot of onions; powdery mildew on field-grown cucumbers; dodder on cucumbers under glass; Baldwin fruit-spot; a *Fusarium* leaf-spot of carnations; *Chaetomium contortum* on barley seedlings.) F. C. Stewart. Pages 15, plates 4.

No. 165 — December.— Report of analyses of Paris green and other insecticides. L. L. Van Slyke. Pages 10.

No. 166 — December.— Commercial feeding stuffs in New York. W. H. Jordan and C. G. Jenter. Pages 42.

No. 167 — December.— A fruit disease survey of the Hudson Valley in 1899. F. C. Stewart and F. H. Blodgett. Pages 34, plates 3, map 1.

No. 168 — December.— Director's report for 1899. W. H. Jordan. Pages 22.

No. 169 — December.— Fertilizing self sterile grapes. S. A. Beach. Pages 41, plates 2.

No. 170 — December.— Diseases and insects injurious to fruits. S. A. Beach, V. H. Lowe and F. C. Stewart. Pages 65.

No. 171 — December.— Animal food for poultry. W. P. Wheeler. Pages 46, plate 1.

No. 172 — December.— The efficiency of a continuous Pasteurizer at different temperatures. H. A. Harding and L. A. Rogers. Pages 24, figs. 2.

No. 173 — December.— Report of analyses of commercial fertilizers for the fall of 1899. L. L. Van Slyke. Pages 22.

W. H. Jordan, *Director*.

New York Agricultural Experiment Station,
Geneva, N. Y., Dec. 30, 1899.

APPENDIX.

PERIODICALS RECEIVED BY THE STATION.

Acker und Gartenbau Zeitung	Complimentary.
Agricultural Education	"
Agricultural Epitomist	"
Agricultural Gazette of New South Wales......	"
Agricultural Student	"
Agricultural Students' Gazette	"
Albany Journal	Subscription.
Allegan Gazette	Complimentary.
American Agriculturist	Subscription.
American Chemical Journal	"
American Chemical Society, Journal	"
American Cultivator	Complimentary.
American Entomological Society, Transactions,	Subscription.
American Fancier	"
American Fertilizer	"
American Florist	"
American Gardening	"
American Grange Bulletin	Complimentary.
American Journal of Physiology	Subscription.
American Monthly Microscopical Journal	"
American Museum of Natural History, Bulletin,	Complimentary.
American Naturalist	Subscription.
American Philosophical Society, Proceedings...	Complimentary.
American Stock Keeper	"
Analyst	Subscription.

Angelica Every Week	Complimentary.
Annales Agronomiques	Subscription.
Annales de l' Institut Pasteur	"
Annals and Magazine of Natural History	"
Annals of Botany	"
Archiv der gesammte Physiologie (Pflueger)	"
Archiv fuer Hygiene	"
Association Belge des Chimistes, Bulletin	Complimentary.
Baltimore Weekly Sun	"
Beet Sugar Gazette	"
Berichte der deutchen botanischen Gesellschaft,	Subscription.
Berichte der deutschen chemischen Gesellschaft,	"
Boletin do Instituto Agronomico do Estado de Sao Paulo	Complimentary.
Boletin de Agricultura, Mineria e Industrias	"
Boletin de Agricultura Tropical	"
Boston Society of Natural History, Proceedings,	Subscription.
Botanical Department, Jamaica, Bulletin	Complimentary.
Botanical Gazette	Subscription.
Botanische Zeitung	"
Botanisches Centralblatt	"
Botaniste, Le	"
Buffalo Society of Natural Sciences, Bulletin	Complimentary.
Canadian Entomologist	Subscription.
Canadian Horticulturist	Complimentary.
Centralblatt fuer Agrikultur-Chemie	Subscription.
Centralblatt fuer Bakteriologie und Parasitenkunde	"
Chemical News	"
Chemical Society, Journal	"
Chemiker Zeitung	"
Chemisches Centralblatt	"
Chicago Dairy Produce	Complimentary.
Cincinnati Society of Natural History, Journal,	"

Columbus Horticultural Society, Journal	Complimentary.
Commercial Gazette	"
Cotton Planters' Journal	"
Country Gentleman	Subscription.
Country World	Complimentary.
Dairy and Creamery	"
DeRuyter Gleaner	"
Detroit Free Press	"
Dietetic & Hygienic Gazette	Subscription.
Deutsche landwirtschaftliche Wochenschrift	Complimentary.
Elgin Dairy Report	"
Elisha Mitchell Scientific Society, Journal	"
English Catalogue of Books	"
Entomological News	Subscription.
Entomological Society of Washington, Proceedings	"
Entomologische Zeitschrift	"
Entomologist	"
Entomologist's Record	"
Fanciers' Review	Complimentary.
Farm and Fireside	"
Farm and Home	"
Farm, Furnace and Factory	"
Farm Journal	"
Farm News	"
Farm Poultry Semi-Monthly	"
Farm, Stock and Home	"
Farmers' Advocate	"
Farmers' Guide	"
Farmers' Home	"
Farmers' Magazine	"
Farmers' Tribune	"
Farmers' Voice	"
Feather	Subscription.

Feathered World	Subscription.
Florist's Exchange	"
Fuehling's landwirtschaftliche Zeitung	"
Garden	"
Gardeners' Chronicle	"
Gardening	"
Geneva Gazette	Complimentary.
Gleanings in Bee Culture	"
Green's Fruit Grower	"
Hedwigia	Subscription.
Herd Register	Complimentary.
Hoard's Dairyman	"
Homestead	"
Indiana Farmer	"
Industrie Laitiere	"
Irrigation Age	"
Ithaca Democrat	"
Jahresberichte der Agrikultur-Chemie	Subscription.
Jahresberichte der Nahrungs-und Genussmittel,	"
Jersey Bulletin	Complimentary.
Journal d' Agriculture Pratique	Subscription.
Journal of Applied Microscopy	"
Journal de Botanique	"
Journal of Experimental Medicine	"
Journal fuer Landwirtschaft	"
Just's Botanischer Jahresbericht	"
Landwirtschaftlicher Jahrbuecher	"
Landwirtschaftlichen Versuchs-Stationen	"
Live Stock Journal	"
Long Island Farmer	Complimentary.
Louisiana Planter	"
Meehan's Monthly	Subscription.
Milk Zeitung	"
Mirror and Farmer	Complimentary.

Montana Fruit Grower	Complimentary.
Monthly Weather Review	"
National Nurseryman	"
National Stockman and Farmer	"
Naturae Novitates	"
Naturaliste	Subscription.
Naturaliste Canadienne	Complimentary.
Nature	Subscription.
Nebraska Farmer	Complimentary.
New England Farmer	"
New York Academy of Science, Annals and Transactions	Subscription.
New York Botanical Garden, Bulletin	Complimentary.
New York Entomological Society, Journal	Subscription.
New York Farmer	Complimentary.
New York Produce Review	"
New York State Granger	"
North American Horticulturist	"
Northwest Pacific Farmer	"
Oesterreichische Chemiker Zeitung	Subscription.
Ohio Poultry Journal	"
Olean Herald	Complimentary.
Oregon Agriculturist	"
Pacific Coast Dairyman	"
Pacific Coast Fanciers' Monthly	Subscription.
Pacific Rural Press	"
Pomona Herald	Complimentary.
Popular Agriculturist	"
Poultry	Subscription.
Poultry Herald	"
Poultry Keeper	Complimentary.
Poultry Monthly	"
Practical Farmer	"
Prairie Farmer	"
Plattsburgh News	"

Progress Agricole et Viticole	Subscription.
Psyche	"
Queensland Agricultural Journal	Complimentary.
Revue Generale de Botanique	Subscription.
Revue Horticole	"
Revue Mycologique	"
Royal Agricultural Society, Journal	"
Rural New Yorker	"
Rural Topics	Complimentary.
Salt Lake Herald	"
Saint Louis Academy of Science, Transactions,	"
Sanitary Inspector	"
Science	Subscription.
Society of Chemical Industry, Journal	"
Societe Entomologique de France	Complimentary.
Societe Mycologique de France	Subscription.
Southern Planter	Complimentary.
Southern Farm Magazine	"
Southwest	"
Southwestern Farmer and American Horticulturist	"
Stazione Sperimentale Agrarie Italiane	"
Strawberry Specialist	"
Suffolk Bulletin	"
Sugar Beet	"
Torrey Botanical Club, Bulletin & Memoirs	Subscription.
Vermont Farmers' Advocate	Complimentary.
Wallace's Farmer	"
Watkins Review	"
Waverly Free Press	"
West Virginia Farm Reporter	"
Western Plowman	"
Wiener illustrierte Garten-Zeitung	Subscription.
Woman's Home Companion	Complimentary.

Zeitschrift fuer analytische Chemie	Subscription.
Zeitschrift fuer Biologie	"
Zeitschrift fuer Entomologie	Complimentary.
Zeitschrift fuer Fleisch und Milch Hygiene....	Subscription.
Zeitschrift fuer Pflanzenkrankheiten	"
Zeitschrift fuer physiologische Chemie	"
Zeitschrift fuer Untersuchung d. Nahrungs- und Genussmittel	"
Zoologischer Anzeiger	"

REPORT

OF THE

Department of Animal Husbandry.

W. H. Jordan, *Director.*

William P. Wheeler, *First Assistant.*

C. G. Jenter, *Assistant Chemist.*

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II. Animal food for poultry.

REPORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY.

COMMERCIAL FEEDING STUFFS IN NEW YORK.*

W. H. JORDAN AND C. G. JENTER.

SUMMARY.

In buying feeding stuffs the farmer should understand both the general character of the material, and the source and general nature of the substances composing it. It is often as important to know that the desired ingredients are not furnished by oat hulls or other indigestible wastes as it is to know the amount of these ingredients.

The terms nitrogenous and carbohydrate are too general to be used without modification in classifying feeding stuffs and the following four classes give a better grouping:

Class I. Contain 30 per ct. to 45 per ct. protein and 50 per ct. to 60 per ct. carbohydrates: Cotton-seed meal, linseed meal and gluten meal.

Class II. Contain 20 per ct. to 30 per ct. protein and 60 per ct. to 70 per ct. carbohydrates: Gluten feeds, Atlas meal, dried brewer's grains, malt sprouts, buckwheat middlings and peas and beans.

* Reprint of Bulletin No. 166.

Class III. Contain 14 per ct. to 20 per ct. protein and 70 per ct. to 75 per ct. carbohydrates: Brans and middlings from wheat and rye and some proprietary mixed feeds.

Class IV. Contain 8 per ct. to 14 per ct. protein and 75 per ct. to 85 per ct. carbohydrates: Cereal grains, cerealine, hominy and oat feeds, corn and oat chops, corn bran, corn germ feed and chop feed in general. Hays and fodders belong here more nearly than elsewhere.

Samples of feed have been collected during the past two winters and analyzed chemically, physically and often microscopically.

Cotton-seed meal should be light yellow, a dark color usually indicating inferiority. Protein may range from 42 per ct. to 46 per ct. or more in good samples. Of 16 samples only two showed evidence of adulteration, but the price did not follow percentage of protein.

Old, or pressure, process linseed meal and new, or naphtha extraction, process meal differ mainly in fat, the former containing three or four pounds more per hundred. Protein of new process meal is perhaps less digestible because of cooking. Nineteen samples were examined and all were good. One was somewhat low in protein with no sign of adulteration.

Gluten meals consist mainly of hard or flinty portions of corn after bran, germ and part of the starch have been removed. They should contain at least 30 per ct. of protein to be classed as meals and may go to 40 per ct. Two samples analyzed were good but the less nitrogenous sold for the higher price.

The gluten feeds are a mixture of the meal with the bran and germs and are less rich in protein than the meals, ranging from 18.8 per ct. to 28.1 per ct. This marked difference seems to be quite constant between the brands, samples of Joliet and Diamond brands running low.

Malt sprouts are the dried shoots from germinated barley. But few samples were analyzed and these were found normal in composition, with from 24.66 per ct. to 30.37 per ct. of protein.

Brewer's grains are the barley grains from which the starch has been removed by growth and fermentation. In fresh state they contain too much water to justify paying a very large price. Dried they furnish about as much protein as the malt sprouts.

Buckwheat middlings and other buckwheat products were found of good quality, but varied widely in protein content, the middlings and feed running from 24.8 per ct. to 33.7 per ct., while the single sample of "ships" showed 33.75 per ct. protein, 9.2 per ct. fat.

Wheat brans were found pure, but not constant in composition, the protein ranging from 13.4 per ct. to 17.1 per ct., and the starch from 17.5 per ct. to 30.6 per ct.

The mixed wheat feeds are combinations of the offals of wheat milling and showed only the natural variations.

Wheat middlings, with one exception, proved normal in composition showing only variations similar to bran and due to same cause, difference in milling processes. Middlings contain more protein, more starch, a little more fat and less fiber than bran and are more digestible. It would seem that preference should not be given the bran as a feed.

Hominy feed or hominy chop consists of the hull, germ and part of the starch of corn grains; and contains less starch, about the same amount of protein and more fiber and fat than corn meal. The samples analyzed appeared quite uniform in composition, except Hudnut's which contained seven per ct. more protein than the average. The average was about 10.5 per ct. protein, 46 per ct. starch and sugar and 7.75 per ct. fat. The prices were much less uniform than the percentages.

In mixed feeds seems to lie the greatest danger from adulteration, a danger which is not entirely guarded against by chemical determination of protein and fat. Oat hulls are extensively used as adulterants in foods of this class. Prices were often equal to what would have bought whole corn and oats. In 26 cases out of 35 examined, the fiber content is larger than the average for whole

oats and much larger than could be given by any straight corn and oats mixture. Some of the feed must have contained at least 50 lbs. of oat hulls per hundred lbs. One oat feed was less digestible by nearly 12 lbs. than whole oats and by nearly 31 lbs. than maize, due largely to the indigestible character of the hulls. The introduction of oat hulls into any mixed feed therefore, increases the amount of indigestible — useless — matter. The material coming from whole grains is also of better quality, being made up more largely of protein and the easily digestible carbohydrates.

Reasons why the source and character of the carbohydrates should be carefully considered in classifying feeding stuffs, are given in full in the bulletin.

Patent foods made up of some simple feed stuff like middlings, corn bran, linseed meal, etc., with a small quantity of charcoal, sulphur, fenugreek, gentian, salt, iron compounds, pepper and other cheap drugs and condiments were found on sale in great numbers and at exorbitant prices, varying from $100 to $500 a ton. This is from $70 to $470 a ton more than the best of them are worth as feeds. Their value as medicines is problematical; if anything, the same effect can be much more cheaply secured by buying the drugs and mixing with the feeds ordinarily used in the stable.

INTRODUCTION.

Commercial cattle foods are an important factor in the animal husbandry of this State. Few farmers, especially dairy farmers, produce all the grain they feed to their stock, for the winter ration generally includes one or more of the by-product feeding stuffs, usually of a more highly nitrogenous character than the home raised grains. Doubtless these purchased materials are often used with profit, while on the other hand, the opinion is freely expressed that it would be economy for many farms to be more fully self-supporting in the matter of the supply of cattle foods. However this may be, it is entirely probable that commercial

feeding stuffs, more particularly those of the highly nitrogenous kinds, will continue to hold their place in the ration, and for this reason it is desirable, even essential, that the purchasers of these commodities shall have an intelligent understanding of their character and value.

It is not surprising that the feeding stuff market is an object of perplexity, as it appears to be, to the majority of would-be buyers. The whole grains as such and as mixed with certain waste products, oil meals, the gluten feeds and meals, breakfast food wastes, brewer's wastes and the so-called patent foods, besides the combination of a variety of materials, good and poor, under the name of "mixed feeds," are all urged upon the attention of the agricultural public. Such a variety of appearance, composition and price must be considered that even the wisest may well hesitate before deciding what articles can be chosen most suitably and economically for a particular use.

In view of the situation as thus outlined, and in order to present certain facts which have been gathered relative to the feeding stuff market in New York, besides paving the way for the largest benefit which may accrue from the new feeding stuff law, it is deemed wise to issue this bulletin. Many of the facts stated are by no means new, and some of the analyses are but a repetition of previous results, yet it is felt that the situation justifies the statement of what is to some extent already familiar knowledge.

INFORMATION WHICH THE BUYER SHOULD POSSESS.

The farmer who wishes to buy a feeding stuff to supplement his home supply of grains should, first of all, understand the general character of any material to which his attention is called, *i. e.,* he should know whether it belongs to the carbohydrate or nitrogenous class of feeding-stuffs.

To the man who is well informed, the trade name is generally indicative of composition. It is true, however, that new materials are constantly appearing in the market and trade names are some-

times deceptive, so that it will be a distinct gain when commercial cattle foods are branded with their real percentages of protein and fat, as presumably will be the case in New York under the operation of the new feeding stuff law.

Moreover, buyers should understand something of the source and general nature of the waste products which make up a large proportion of our commercial feeding stuffs. The fact that any material is an offal from a manufacturing process may or may not mean that it is of inferior nutritive value. As an illustration, certain parts of the maize kernel which appear in the gluten meals and hominy wastes are from the parts of the grain in no way inferior, whereas oat hulls are the least valuable part of the seed. These facts establish an important distinction between the by-products from starch and glucose manufacture and those from the manufacture of breakfast foods from oats. For this and similar reasons, the ingredients of the various mixed feeding stuffs should be clearly stated for the buyer's benefit, and the provision of our new feeding stuff law which, among other things, makes illegal the abominable practice of adulterating corn meal with oat hulls, without the knowledge of the purchaser, to be sold to him as mixed feed from corn and oats, is a step in the direction of enforced honesty in the cattle food trade.

CLASSIFICATION OF FEEDING STUFFS.

Cattle foods are often classified in a popular way as "carbohydrate" and "nitrogenous." Such a division into two classes, based upon the proportions of carbohydrates and protein, is not rational. The fact is, there is a quite uniform gradation in the percentage of protein in feeding stuffs from cotton-seed meal to wheat straw and there seems to be no natural point of separation into two groups. It is absurd to place wheat bran with 16 per ct. of protein in the same group with cotton-seed meal with 45 per ct. of protein.

As a matter of convenience and a nearer approximation to accuracy, it seems advisable to classify feeding stuffs into at least four groups and even with this arrangement the range of composition within any one group is quite wide.

The following are the classes suggested, with some of their principal members:

Class I. 30 to 45 per ct. protein and 50 to 60 per ct. carbohydrates, including cotton-seed meal, linseed meal and the gluten meals, such as the Chicago, King, Cream and Hammond.

Class II. 20 to 30 per ct. protein and 60 to 70 per ct. of carbohydrates, including gluten feeds, such as the Buffalo, Golden, Diamond, Davenport, Climax and Standard, as now made, Atlas meal, dried brewer's grains, malt sprouts, buckwheat middlings and peas and beans.

Class III. 14 to 20 per ct. of protein and 70 to 75 per ct. of carbohydrates, including brans and middlings from wheat and rye, certain so-called mixed feeds of a proprietary character, these being in part oat feeds fortified with some more highly nitrogenous material.

Class IV. 8 to 14 per ct. of protein and 75 to 85 per ct. of carbohydrates, including barley, corn, oats, rye, wheat, cerealine, hominy and oat feeds, corn and oat chop, corn bran, corn germ feed and chop feed in general.

The hays and other fodders belong in Class IV more nearly than in any other.

ANALYSES AND COMMENTS.

THE SAMPLES AND THEIR EXAMINATION.

The samples, the analyses of which appear in this bulletin, were mostly selected in this State during the past two winters by authorized representatives of this Station. In a majority of cases the selling prices are given, these being the ton prices stated to our agent by the dealers where the sample was procured. It is

to be noted that the names of manufacturers are not given in connection with various samples. As many of the goods were not branded by the name of the maker or importer, it was thought best, in order to avoid possible error, to consider the samples wholly from the standpoint of what inspection has shown them to be.

These samples were submitted to more than the usual chemical analysis,— they were carefully examined as to the nature of their constituents, special attention being given to the feeds of a mixed character and to those coming under the head of proprietary or condimental foods.

Moreover, the chemical analysis has been made to include even more than usual. In the case of the mixed and chop feeds the amount of fiber present is often suggestive as to the origin of their constituents and besides it is interesting and useful to know to what extent, especially in the corn and oat offals, the starch and other equally valuable carbohydrates have been removed.

COTTON-SEED MEAL.

This feeding stuff is a by-product of the manufacture of cotton-seed oil. The seed of cotton, after the long fibers are removed by ginning, consists of a kernel enclosed by a thick hull. This hull, after removal, constitutes a low grade feeding stuff which is known in the market as cotton-seed hulls. The hulled kernels are crushed and after they are cooked the oil is removed by pressure, leaving a cake residue, nearly 800 pounds from a ton of seed, which after grinding we know as cotton-seed meal. The color of this meal should be light yellow and it should have a clean nutty flavor. The percentage of protein in the best product generally ranges between 42 per ct. and 46 per ct. Among the causes of inferiority are the presence of hulls and injury due to fermentations, but these conditions are indicated by the color and flavor. Dark colored cotton-seed meal should be regarded with suspicion.

Samples of Cotton-Seed Meal Collected in New York During 1898 and 1899.

Station number.	Sample: Where collected.	Ton selling price	Station number	Sample: Where collected.	Ton selling price.
438..	Elmira	$23 00	553..	Florida	$22 00
439..	Elmira	24 00	656..	Sidney	18 00
465..	Buffalo	28 00	660..	Delhi	23 00
487..	Syracuse	28 00	672..	Hobart	23 00
490..	Syracuse	23 00	673..	Hobart	22 00
500..	Oswego	23 00	692..	Middlebury	......
518..	Utica	23 00	705..	......	......
545..	Middletown	......	706..	......	......
552..	Florida	11 00			

Analyses of Samples of Cotton-Seed Meal.

Station number.		Water.	Ash.	Protein.	Fiber.	Starch and sugar.	Total nitrogen-free extract.	Fat.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
438.	Cotton-seed meal	5.10	6.51	46.75	5.07	13.2	23.78	12.79
439.	Cotton-seed meal	7.42	8.15	36.25	5.29	24.7	34.74	8.15
465.	Cotton-seed meal	7.05	6.00	42.25	5.20	20.1	29.62	9.88
487.	Cotton-seed meal	6.35	6.86	46.00	6.10	14.3	25.99	8.70
490.	Cotton-seed meal	7.18	6.54	43.56	7.30	15.4	27.86	7.56
500.	Cotton-seed meal	7.11	6.19	41.68	6.82	12.7	26.28	11.92
518.	Cotton-seed meal	7.05	6.02	48.81	4.68	16.4	24.59	8.85
545.	Cotton-seed meal	7.40	5.98	46.56	5.08	13.7	25.71	9.27
552.	Cotton-seed feed	7.81	3.63	10.75	33.37	6.6	42.03	2.41
553.	Cotton-seed meal	6.24	5.90	50.69	2.92	13.7	23.82	10.43
656.	Cotton-seed meal	6.94	6.00	43.75	5.81	....	23.24	14.26
660.	Cotton-seed meal	7.77	6.85	45.50	4.27	....	25.56	10.05
672.	Cotton-seed meal	7.21	5.69	49.06	4.68	....	22.33	11.03
673.	Cotton-seed meal	7.01	5.92	44.38	5.59	....	23.94	13.16
692.	Cotton-seed meal	7.14	5.90	43.43	7.24	....	23.51	12.78
705.	Cotton-seed meal	7.45	5.39	28.68	16.57	....	34.62	7.29
706.	Cotton-seed meal	6.19	6.50	46.56	5.38	....	24.49	10.88
	Average all but 439, 552 and 705	6.84	6.21	45.64	5.44	....	25.05	10.82
	Average starch and sugar, eight samples.	....	....	....	....	14.9	....	....

In all but two cases the samples of cotton-seed meal have been found to have a satisfactory composition. Two samples, Nos. 439 and 705, showed so low a protein content as to justify the conclusion that they were from adulterated stock. They were dark colored. There is no question that adulterated meal is in the market, as is clearly proven in Bulletin No. 56 from the Massachusetts Experiment Station, where the analyses are given of

eighteen samples of inferior goods found in the market of that State.

This adulteration is probably brought about by grinding in hulls. These meals were sold in part under the name Sea Island Cotton-seed and probably were in all cases a mixture of the yellow meal and finely ground hulls. Farmers should avoid such goods.

The sample of cotton-seed feed No. 552, the analysis of which appears in the above table as a means of contrasting it with cotton-seed meal, consists of cotton-seed hulls and is very inferior in value.

LINSEED MEAL.

Linseed meal is a by-product from the manufacture of linseed oil. It is often called oil meal. "Old process" oil meal is that from which the oil is obtained by pressure and "new process" meal is the residue afer treating the crushed seed with a light naphtha. The former contains the more fat although owing to a change in the process the "old process" meal contains less fat than was formerly the case.

By the older methods about 35 lbs. of oil was obtained from 100 lbs. of seed, but now the output is larger.

The relative value of "old process" and "new process" meal is much discussed. Certainly there is no appreciable difference in palatableness and healthfulness, and no large difference in nutritive qualities. The protein of the latter appears to be somewhat less digestible, due doubtless to the increased cooking to which the new process product is subjected.

SAMPLES OF LINSEED MEAL COLLECTED IN NEW YORK DURING 1898 AND 1899.

Station number.	Sample: Where collected.	Ton selling price.	Station number.	Sample: Where collected.	Ton selling price.
428..	Union Springs	......	498..	Fulton	$25 00
435..	Fayetteville	......	501..	Oswego	25 00
436..	Elmira	$28 00	514..	Watertown	25 00
440..	Elmira	30 00	517..	Utica	28 00
443..	Corning	30 00	529..	Binghamton	28 00
455..	Hornellsville	30 00	670..	Hobart	30 00
464..	Buffalo	30 00	694..	Cobleskill	......
471..	Waterloo	28 00	698..	Otego	30 00
481..	Geneva	27 00	699..	Otego	30 00
491..	Syracuse	30 00			

ANALYSES OF SAMPLES OF LINSEED MEAL.

Station number.		Water.	Ash.	Protein.	Fiber.	Starch and sugar.	Total nitrogen-free extract.	Fat.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
428.	Linseed meal, old process.	8.87	5.51	37.25	7.29	10.1	34.64	6.44
435.	Linseed meal, old process.	6.84	5.35	37.25	7.43	7.4	36.21	6.92
436.	Linseed meal, old process.	8.68	5.45	38.06	7.38	9.4	34.31	6.12
440.	Linseed meal, old process.	8.34	5.39	35.00	8.55	15.0	35.40	7.32
443.	Linseed meal, old process.	8.53	5.14	36.31	7.60	12.2	36.48	5.94
455.	Linseed meal, old process, Buffalo	8.03	5.35	36.69	6.94	11.6	35.53	7.46
464.	Linseed meal, old process.	8.97	4.85	35.81	7.10	10.4	35.76	7.51
471.	Linseed meal, old process.	8.10	4.86	36.06	6.82	11.4	35.67	8.49
481.	Linseed meal, old process, National	7.75	5.82	35.81	7.54	7.5	36.17	6.91
491.	Linseed meal, old process.	7.37	5.29	36.94	7.43	11.4	36.04	6.93
501.	Linseed meal, old process.	9.43	5.51	28.69	8.59	22.7	40.15	7.63
517.	Linseed meal, old process.	8.45	5.31	36.19	7.03	13.9	34.16	8.86
529.	Linseed meal, old process, Empire	6.89	5.22	38.19	7.11	14.8	36.87	5.72
699.	Linseed meal, old process.	9.76	5.37	32.13	8.16	....	36.12	8.46
	Average	8.29	5.32	35.74	7.50	12.1	35.96	7.19
498.	Linseed meal, new process, Cleveland	10.53	5.01	36.63	8.69	18.4	36.23	2.91
514.	Linseed meal, new process.	10.08	4.95	37.56	7.22	19.1	37.04	3.15
670.	Linseed meal, new process.	10.25	5.33	35.81	8.57	....	35.99	4.05
694.	Linseed meal, new process, Cleveland	9.87	5.36	35.19	8.48	....	36.31	4.79
698.	Linseed meal, new process.	9.34	5.50	35.50	9.08	....	37.62	2.96
	Average	10.01	5.23	36.14	8.41	18.7	36.64	3.57

The linseed meal found in New York seems to be quite uniformly good. This appears to be the case in all States. Adulteration of this feeding stuff is evidently not much practiced. Sample No. 501 contains less protein than it should, but no explanation of this fact was discovered. Linseed meal is certainly one of our most valuable and reliable commercial feeding stuffs, though it is evidently expensive as compared with some other articles.

GLUTEN MEALS.

As found in the market the principal gluten products are corn bran, consisting mostly of the hulls and germ of the maize kernel, the gluten meals which come principally from the hard or flinty

portions of this seed and the gluten feeds which are a mixture of the corn bran and gluten meal. Of these the gluten meals are the most valuable. They contain between 30 and 40 per ct. of protein and are practically as digestible as corn meal.

SAMPLES OF GLUTEN MEAL COLLECTED IN NEW YORK DURING 1898 AND 1899.

Station number.	Sample: Where collected.	Ton selling price.
494..	Syracuse	$18 00
658..	Sydney Center	20 00

ANALYSES OF SAMPLES OF GLUTEN MEAL.

Station number.		Water.	Ash.	Protein.	Fiber.	Starch and sugar.	Total nitrogen-free extract.	Fat.
		Per ct.	Per ct.	Per ct.	Per ct	Per ct.	Per ct.	Per ct.
494.	Gluten "M"	6.51	1.65	39.08	1.50	35.7	46.56	4.7
658.	Chicago gluten meal	10.0	.84	36.25	1.92	....	48.60	2.39

The above samples of gluten meal are fully up to the standard, No. 494 being especially rich in protein.

GLUTEN FEEDS.

As previously stated, gluten feeds are a mixture of all the by-products which are left after removing a portion of the starch from the maize kernel. They contain less protein than the gluten meals and much more than the corn brans.

SAMPLES OF GLUTEN FEEDS COLLECTED IN NEW YORK DURING 1898 AND 1899.

Station number.	Sample: Where collected.	Ton selling price.	Station number.	Sample: Where collected	Ton selling price.
422..	Union Springs	......	536..	Whitney's Point	......
427..	Dryden	$16 00	418..	Geneva	......
521..	Norwich	17 00	479..	Geneva	$16 50
525..	Sidney	17 00	495..	Syracuse	16 00
527..	Sidney	17 50	424..	Dryden	13 00
688..	Albany	......	533..	Binghampton	18 00
496..	Syracuse	15 00	531..	Binghampton	17 75
543..	Middletown	......	743..	Syracuse	......
555..	Florida	17 00	508..	Pulaski	18 00
437..	Elmira	14 00	535..	Whitney's Point	18 00

Analyses of Samples of Gluten Feeds.

Station number.		Water.	Ash.	Protein.	Fiber.	Starch and sugar.	Total nitrogen-free extract.	Ether extract.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
422.	Buffalo gluten feed	8.66	3.53	27.19	6.71	21.9	50.09	3.82
427.	Buffalo gluten feed	8.15	4.10	27.63	6.18	21.2	49.27	4.67
521.	Buffalo gluten feed	9.14	3.02	27.06	7.00	21.5	50.40	3.38
525.	Buffalo gluten feed	7.66	3.01	26.06	2.46	26.5	57.43	3.38
527.	Buffalo gluten feed	8.62	0.84	21.31	6.24	34.0	59.46	3.53
688.	Buffalo gluten feed	6.87	2.70	27.38	6.76	....	52.81	3.48
	Average	8.18	2.87	26.10	5.89	25.0	53.25	3.71
496.	Climax gluten feed......	7.95	0.94	24.56	1.31	26.5	60.43	4.81
543.	Davenport gluten feed...	7.56	1.11	23.56	6.83	26.2	55.46	5.48
555.	Davenport corn feed.....	8.07	1.23	22.94	6.33	28.8	56.75	4.68
	Average	7.82	1.17	23.25	6.58	27.5	56.10	5.08
437.	Diamond gluten feed....	7.74	7.90	20.56	6.06	28.8	54.34	3.40
536.	Diamond gluten feed....	8.17	0.83	20.00	6.51	29.4	59.28	5.21
	Average	7.96	4.36	20.28	6.29	29.1	56.81	4.30
418.	Joliet gluten feed	8.82	0.92	18.80	6.58	32.2	60.39	4.49
479.	Joliet gluten feed	7.80	0.87	19.56	6.43	30.2	60.66	4.68
	Average	8.31	.90	19.18	6.50	31.2	60.52	4.59
495.	"R" gluten feed........	7.68	1.13	28.13	4.50	36.3	54.88	3.68
424.	Peoria gluten feed	8.38	0.97	20.69	5.87	27.7	57.05	7.04
533.	Peoria gluten feed	8.65	2.04	26.00	7.10	25.1	52.41	3.80
	Average	8.51	1.50	23.34	6.98	26.4	54.73	5.42
531.	Empire gluten feed......	8.01	1.11	24.43	7.21	16.7	53.85	5.39
743.	Waukegan gluten feed...	6.19	1.03	24.31	7.48	....	56.34	4.65
508.	Gluten feed	7.58	.93	21.50	5.66	26.9	57.55	6.78
535.	Gluten feed	8.26	.91	23.37	6.05	31.	56.81	4.60
	Average of all analyses.	8.00	1.96	23.75	5.99	27.3	55.75	4.55

The above named materials, all of which pass under the name of "gluten feeds," show a range of protein content from 18.8 per ct. to 28.1 per ct. These differences appear to pertain more largely to brands than to samples, the Joliet and Diamond brands falling considerably below the others in protein content. However this may be, the facts as given are a good illustration of the need of branding commercial feeding stuffs with a statement of their composition, for unless this is done a gluten feed passes for such without the buyer having a definite knowledge of what it really is, and besides, this class of materials is often confounded with gluten meals which are of superior value, both as to composition and digestibility.

BREWER'S AND DISTILLERY RESIDUES.

The so-called brewer's residues are those resulting from the operations of malting and brewing.

In malting, the barley grains are allowed to sprout, and before the malted grains are crushed for brewing purposes these sprouts are removed, which in an air dry condition are known in the market as malt sprouts.

From the malted grains is extracted the sugar that has formed from the starch during the germination which has occurred, and these extracted grains after drying appear in the market as dried brewer's grains. They are much poorer in starch and richer in protein than the entire barley grain and are properly regarded as a nitrogenous feeding stuff.

SAMPLES OF BREWER'S RESIDUES COLLECTED IN NEW YORK DURING 1898 AND 1899.

Station number.	Sample: Where collected.	Ton selling price.	Station number.	Sample: Where collected.	Ton selling price.
489..	Syracuse	$10 00	1258..	Syracuse	......
504..	Oswego	12 00	1259..	Syracuse	......
538..	Geneva	12 00	724..	Waterloo	......

ANALYSES OF SAMPLES OF BREWER'S RESIDUES.

Station number.		Water.	Ash.	Protein.	Fiber.	Starch and sugar.	Total nitrogen-free extract.	Fat.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
489.	Malt sprouts	6.00	5.73	24.66	13.29	22.3	47.32	3.00
504.	Malt sprouts	3.26	7.62	30.37	9.14	21.4	47.17	2.44
538.	Malt sprouts	5.88	5.86	27.69	10.34	21.9	46.72	3.51
	Averages	5.05	6.40	27.58	10.93	....	47.06	2.98
	Average starch and sugar	.....	....	.....	.....	21.9	.....	.....
1258.	Brewer's grains, lager, fresh	77.0	0.66	6.99	2.90	....	11.01	1.44
	Brewer's grains, lager, air dry	6.95	2.69	28.31	11.75	....	44.46	5.84
1259.	Brewer's grains, ale, fresh	78.8	0.68	5.45	3.19	....	10.43	1.45
	Brewer's grains, ale, air dry	6.34	3.02	24.13	14.14	....	45.95	6.42
724.	Distillery waste, fresh.	91.3	0.32	2.98	0.84	....	3.45	1.11
	Distillery waste, air dry	6.46	3.39	32.0	9.03	....	37.20	11.92

Not many samples of brewer's wastes were obtained, and those which were analyzed were not unusual in composition.

But few analyses have been made in this country of distillery waste. No. 724 was obtained from a distillery at Waterloo and in the fresh condition is somewhat used by farmers in the immediate vicinity. It is to be noted that the proportion of dry matter in the fresh material is very small, only 8.7 per ct. or one-tenth as much as in the ordinary grains in an air dry condition. The cost should be only one-tenth also. This observation applies in a general way to the fresh brewer's grains which proved to be nearly three-quarters water.

BUCKWHEAT MIDDLINGS.

There are several offals from the milling of buckwheat, including the hulls, the bran and middlings. The latter contain a generous proportion of protein, usually not less than twenty-five, and they are properly classed among our nitrogenous feeding stuffs. Oftentimes the bran and middlings are mixed together when the percentage of protein is reduced in proportion to the

amount of bran present. The bran contains from 10 per ct. to 12 per ct. of protein and the hulls from 3 per ct. to 5 per ct.

SAMPLES OF BUCKWHEAT MIDDLINGS COLLECTED IN NEW YORK DURING 1898 AND 1899.

Station number.	Sample: Where collected.	Ton selling price.	Station number.	Sample: Where collected.	Ton selling price.
426..	Smithboro	$13 00	659..	Delhi	$16 00
433..	Hornellsville	14 00	728..	Lawyersville	......
499..	Fulton	14 00	696..	Oneonta	13 00
511..	Watertown	14 00	510..	Watertown	14 00
530..	Binghamton	14 00			

ANALYSES OF SAMPLES OF BUCKWHEAT MIDDLINGS.

Station number.		Water.	Ash.	Protein.	Fiber.	Starch and sugar.	Total nitrogen-free extract.	Fat.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
426.	Buckwheat middlings...	10.39	4.24	27.25	5.73	21.9	45.06	7.33
453.	Buckwheat middlings...	11.14	5.01	27.38	5.55	30.3	43.29	7.63
499.	Buckwheat middlings...	9.90	5.14	30.31	7.68	17.4	38.96	8.01
511.	Buckwheat middlings...	12.77	4.29	26.44	2.75	24.2	46.87	6.88
530.	Buckwheat middlings...	11.30	4.50	24.81	4.29	35.8	48.55	6.55
728.	Buckwheat middlings...	13.40	4.65	25.31	9.42	....	41.05	6.17
696.	Buckwheat, "feed"....	11.50	4.85	26.38	12.91	....	37.75	6.60
510.	Buckwheat, "ships" ...	12.19	5.78	33.75	4.78	15.6	34.30	9.20
	Averages	11.56	4.81	27.70	6.64	....	41.99	7.30
	Average starch and sugar, 6 samples...	.....	....	.....	.....	24.2	.....	....

No one of the lots of buckwheat middlings sampled seems to have been of inferior quality. There is seen to be a wide variation in the protein content, however, as it ranges from 24.8 per ct. to 33.75 per ct. in the various samples.

MILLING OFFALS FROM WHEAT.

The offals from milling wheat are probably the oldest, best known and most popular by-product feeding stuffs found in the market. These consist of the brans, middlings and low grade flours.

The prominent differences between these products and the original wheat kernels, and especially between these and the fine

flour designed for human consumption, are the larger proportions in them of mineral matter and protein. This is due to the fact that these by-products consist of the outer portions of the wheat kernel which are relatively rich in mineral and nitrogen compounds.

SAMPLES OF WHEAT BRAN COLLECTED IN NEW YORK IN 1898 AND 1899.

Station number.	Sample: Where collected.	Ton selling price.	Station number.	Sample: Where collected.	Ton selling price.
429..	Victor	......	478..	Geneva	$16 00
430..	Dryden	$13 50	484..	Auburn	15 00
434..	Delhi	......	519..	Utica	15 00
442..	Corning	15 00	549..	Florida	15 50
449..	Hornellsville	14 00	551..	Florida	16 00
468..	Rochester	14 50	682..	New Paltz	16 00

ANALYSES OF SAMPLES OF WHEAT BRAN.

Station number.		Water.	Ash.	Protein.	Fiber.	Starch and sugar.	Total nitrogen-free extract.	Fat.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
429.	Wheat bran, spring	9.15	6.18	16.37	10.20	18.2	52.99	5.11
430.	Wheat bran	8.96	5.81	16.37	10.32	18.5	53.45	5.09
434.	Wheat bran	8.66	4.63	13.37	13.64	22.9	56.30	3.40
442.	Wheat bran	8.63	4.45	16.00	10.11	17.5	55.22	5.59
449.	Wheat bran, western	9.02	6.84	17.13	9.32	20.1	52.05	5.64
468.	Wheat bran	9.27	6.43	15.94	9.37	19.7	53.99	5.00
478.	Wheat bran	7.81	5.15	15.25	7.13	30.6	60.28	4.38
484.	Wheat bran	10.67	4.82	14.94	7.52	26.8	56.58	5.47
519.	Wheat bran, spring	10.71	6.52	16.06	8.86	20.0	52.62	5.23
549.	Wheat bran	9.29	6.84	13.75	9.35	19.4	55.87	4.90
682.	Wheat bran	11.35	3.45	13.75	5.67	....	62.19	3.59
	Average of 12 samples wheat bran	9.49	5.47	15.36	8.94	....	55.95	4.79
	Average starch and sugar, 11 samples	.....	....	.....	.....	22.8	.....	....

As a rule the wheat brans which have been sampled have been found to be a pure wheat offal. They are seen to vary somewhat in composition, the protein in 12 cases ranging from 13.4 per ct. to 17.1 per ct. The starch content is also far from constant, the extreme percentages being 17.5 per ct. and 30.6 per ct. These variations are doubtless due to differences in the composition of the wheat and to unlike conditions of milling. On the whole,

however, wheat bran is one of our most reliable commercial feeding stuffs.

SAMPLES OF MIXED WHEAT OFFALS COLLECTED IN NEW YORK IN 1898 AND 1899.

Station number.	Sample: Where collected.	Ton selling price.	Station number.	Sample: Where collected.	Ton selling price.
551..	Florida	$16 00	685..	Weldon	$16 00
431..	Dryden	14 50	653..	Sidney	18 00
700..	Otego	18 00	676..	Kingston	18 00
655..	Sidney	......	687..	Walkill	18 00

ANALYSES OF SAMPLES OF MIXED WHEAT OFFALS.

Station number.		Water.	Ash.	Protein.	Fiber.	Starch and sugar.	Total nitrogen-free extract.	Fat.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
551.	Ship stuff	10.34	4.50	15.31	5.74	37.4	59.99	4.12
431.	Royal wheat feed	8.88	5.04	17.94	7.73	29.3	55.17	5.24
700.	Royal wheat feed	10.57	4.95	16.56	9.28	....	53.64	5.00
655.	Buckeye wheat feed	10.77	5.13	15.38	7.62	....	55.98	5.12
685.	King winter wheat feed.	10.18	6.27	16.63	7.40	....	54.77	4.75
653.	New Eng. mixed feed	9.88	5.04	15.69	8.13	....	55.67	5.59
676.	Mixed feed	10.76	5.25	15.	7.26	....	56.96	4.77
687.	Mixed feed	10.94	4.89	16.13	8.09	....	54.90	5.05

Many millers are not separating the various wheat offals, but are running them together and are selling the mixture under the term "mixed feed" or some proprietary name. The above figures show a composition such as we would expect these mixtures to have.

SAMPLES OF WHEAT MIDDLINGS COLLECTED IN NEW YORK DURING 1898 AND 1899.

Station number.	Samples: Where collected.	Ton selling price.	Station number.	Samples: Where collected.	Ton selling price.
421..	Union Springs	......	671..	Hobart	$19 00
423..	Dryden	$14 50	675..	Kingston	18 00
441..	Corning	16 00	678..	Kingston	18 00
452..	Hornellsville	14 00	680..	Kingston	19 00
469..	Rochester	......	683..	....	......
477..	Geneva	16 00	684..	New Paltz	......
483..	Auburn	16 00	689..	Albany	20 00
515..	Watertown	16 00	693..	Cobleskill	19 00
516..	Watertown	18 00	701..	Union	19 00

ANALYSES OF SAMPLES OF WHEAT MIDDLINGS.

Station number.		Water.	Ash.	Protein.	Fiber.	Starch and sugar.	Total nitrogen-free extract.	Ether extract.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct	Per ct.	Per ct.
421.	Middlings	9.77	3.78	18.75	6.07	32.5	55.54	6.09
423.	Middlings, Pillsbury's brown	8.62	5.10	17.43	10.05	21.2	53.12	5.68
441.	Middlings	10.69	3.47	17.06	3.45	42.9	60.58	4.75
452.	Middlings, Minn. hard red	9.97	5.00	18.13	7.58	22.5	53.19	6.13
469.	Middlings, winter wheat.	8.56	4.88	19.50	5.71	29.0	54.29	7.06
477.	Middlings, western	9.66	3.23	15.94	3.95	44.9	62.00	5.23
483.	Middlings, winter wheat.	11.41	2.52	14.81	2.60	53.2	64.76	3.90
515.	Middlings, western	10.08	4.51	16.06	5.59	33.3	59.18	4.58
516.	Middlings, red dog	9.44	3.60	20.68	2.45	35.7	58.53	5.30
671.	Middlings, red dog	9.52	2.70	10.81	4.27	....	64.19	8.51
675.	Middlings	10.39	4.86	17.63	7.20	....	54.55	5.37
678.	Middlings, daisy b	10.78	4.86	18.25	7.44	....	53.23	5.44
680.	Middlings, Adrian	10.61	2.74	20.06	2.17	....	59.19	5.23
683.	Middlings	10.10	4.08	17.19	6.34	....	56.22	6.07
684.	Middlings	9.94	4.48	19.81	5.92	....	53.63	6.22
689.	Middlings	10.14	4.10	18.00	5.66	....	56.50	5.60
693.	Middlings, shorts	10.71	2.97	17.88	3.57	....	59.43	5.44
701.	Middlings	9.63	2.39	15.31	2.64	....	66.25	3.78
	Averages	10.00	3.85	17.41	5.15	....	58.01	5.58
	Average starch and sugar, 9 samples	.....	....	.....	.....	35.0	.....	....

With the exception of sample No. 671, the composition of the middlings does not exhibit any unusual variations. The explanation of the variations which occur in bran apply equally to middlings. The latter appear to be fully the equal of the former in uniformity and reliability. The middlings as found in New York seem to differ from the brans in containing on the average materially more protein, and as is to be expected, more starch, the proportion of fiber being less. Digestion experiments, so far conducted, leave no doubt as to the greater digestibility of the middlings, a conclusion which is entirely consistent with related facts. Why, then, bran should be an apparently more popular dairy feeding stuff than middlings is not clear. There are substantial reasons for believing that the popular judgment is in error, a statement which is worthy the attention of dairymen.

It is recognized, of course, that so-called middlings are sometimes a catch-all for inferior refuse materials, and if this condition of affairs is found to be prevalent in New York it may be necessary

to bring these goods under the provisions of the feeding stuff law, in order that they may be inspected.

HOMINY FEED OR CHOP.

The hominy which is manufactured for human consumption consists of the hard part of the maize kernel. The hull and germ together with more or less of the starchy portions of the kernel make up the waste of hominy manufacture, and are known as hominy feed or chop.

This material differs somewhat from corn meal in composition, the starch being less, the fiber and fat somewhat more, and the protein about the same, yet nutritively speaking, corn meal and hominy feed are not greatly unlike.

Moreover, hominy feed appears to be quite uniform in composition, as is shown by the analyses which are given in this connection.

SAMPLES OF HOMINY FEEDS COLLECTED IN NEW YORK DURING 1898 AND 1899.

Station number.	Samples: Where collected.	Ton selling price.	Station number.	Samples: Where collected.	Ton selling price.
523..	Norwich	$16 00	546..	Middletown	......
526..	Sidney	......	550..	Florida	$14 50
528..	Sidney	15 00	652..	Sidney	19 00
534..	Whitney's Point	16 50	669..	Delhi	18 00
537..	Geneva	14 00	674..	Hobart	20 00

ANALYSES OF SAMPLES OF HOMINY FEED.

Station number.		Water.	Ash.	Protein.	Fiber.	Starch and sugar.	Total nitrogen-free extract.	Fat.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
523.	Hominy feed	6.13	3.11	10.94	4.59	41.7	66.31	8.92
526.	Hominy feed	7.76	3.03	10.75	4.42	42.9	64.63	9.41
528.	Hominy feed	6.60	2.44	10.38	3.44	52.9	70.47	6.67
534.	Hominy feed	9.70	2.32	10.25	3.63	50.8	67.27	6.83
537.	Hominy feed	10.56	2.26	10.37	4.35	45.8	65.88	6.58
546.	Hominy feed	8.71	2.48	10.63	3.85	45.1	66.90	7.43
550.	Hominy meal	8.28	2.77	10.81	4.43	42.9	65.27	8.44
652.	Hominy feed	10.19	2.47	10.69	3.80	....	64.52	8.33
669.	Hominy, Hudnut's	10.28	3.37	17.69	4.83	....	58.09	5.74
674.	Hominy feed	10.14	2.88	10.56	4.64	....	62.85	8.93
	Averages, excluding No. 669	8.83	2.71	10.60	4.20	....	65.22	7.73
	Average starch and sugar, 7 samples	.....	....	.....	....	46.0	.....	....

MIXED FEEDS.

There has appeared in the feeding stuff trade during recent years a class of materials which, as a rule, are mixtures either of some cereal grain with certain manufacturers' by-products or of two or more by-products. To these are applied a variety of names, often of a proprietary character, some of which give no hint of the nature of the mixture, and others, if taken for their face value, indicate the sources of the ingredients. If these mixtures were always made up wholly of high grade materials, they would need less attention than they now really demand. As a matter of fact, many of them are found to contain a constituent of very inferior value, viz.: oat hulls, a by-product from the manufacture of breakfast foods. Not only have large manufacturing establishments used these hulls in compounding mixtures, but some local millers in the State of New York have bought them to grind with corn and sometimes with mill wastes, the mixed product being sold as "mixed feed," "corn and oat feed," "chop feed," and so on. To quite an extent, at least, farmers have been ignorant of the real nature of these feeds, and as this Station has abundant evidence, have paid for them prices equal to the cost of whole corn and oats. If our millers have been aware of the inferiority of oat hull mixtures, and have sold such goods to consumers who were ignorant of what they were buying, it is charitable to say no more than that the rules of an honorable business policy have been severely violated.

In order that there may be no misapprehension as to the real character of oat hulls, attention is called to their composition and their relation to the kernel.

It was found at the Ohio Experiment Station that with 69 varieties of oats the hull constituted from 24.6 per ct. to 35.2 per ct. of the weight of the grain, the average being 30 per ct. From other sources we learn what is the composition of the dry matter of the whole grain, the hulls and the hull-less kernels.

ANALYSES OF OATS, OAT HULLS AND OAT KERNELS.

	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
Whole grain, 30 samples	3.4	13.2	10.8	67.0	5.6
Hulls, 3 samples	7.3	3.4	37.2	50.8	1.3
Hulled kernels, 179 samples	2.3	15.4	1.5	72.1	8.7

The lesson to be drawn from these figures is clear, which is that oat hulls are the inferior portion of the grain. They have but little protein and a large proportion of woody fiber, nearly as much as oat straw. The kernels are the easily digestible and nutritious portion of the oat grains and are surrounded by the tough, woody hulls, which in whatever light we regard them can hardly have a greater value for feeding purposes than straws. Below can be seen the prices and composition of a considerable number of these mixed feeds, not all of which, however, contain oat offals.

SAMPLES OF VARIOUS OAT FEEDS AND MIXED FEEDS, PROPRIETARY AND OTHERWISE, COLLECTED IN NEW YORK DURING 1898 AND 1899.

Station number.	Sample: Where collected.	Selling price.	Station number.	Sample: Where collected.	Selling price.
425..	Smithboro	......	472..	Geneva	$20 00
649..	Binghamton	$20 00	480..	Geneva	15 00
433..	Smithboro	......	482..	Auburn	19 00
679..	Kingston	20 00	492..	Syracuse	16 00
466..	Buffalo	16 00	497..	Fulton	25 00
467..	....	......	548..	Syracuse	15 00
540..	Buffalo	15 00	677..	Kingston	17 50
419..	Union Springs	......	695..	Oneonta	18 00
473..	Geneva	15 00	697..	Oneonta	18 00
507..	Pulaski	15 00	703..	Owego	19 00
681..	New Paltz	16 00	704..	....	......
503..	Oswego	15 00	542..	Middletown	......
654..	Sidney	20 00	648..	Binghamton	20 00
668..	Delhi	16 00	554..	Florida	12 00
432..	Victor	......	657..	Sidney Center	19 00
544..	Middletown	......	420..	Union Springs	......
444..	Corning	16 00	650..	Binghamton	16 00
447..	Corning	15 00			

ANALYSES OF SAMPLES OF VARIOUS OAT FEEDS, AND MIXED FEEDS, PROPRIETARY AND OTHERWISE.

Station number.		Water.	Ash.	Protein.	Fiber.	Starch and sugar.	Total nitrogen-free extract.	Fat.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
425.	H. O. stand. dairy food.	8.41	3.14	17.50	10.43	31.7	55.31	5.21
649.	H. O. stand. dairy food.	7.92	3.49	16.31	12.59	....	55.40	4.29
	Average	8.17	3.31	16.90	11.51	....	55.36	4.75
433.	H. O. stand. horse food.	8.64	3.37	11.69	10.26	36.7	62.35	3.69
679.	H. O. stand. horse food.	9.27	3.29	10.69	11.00	....	61.49	4.26
	Average	8.96	3.33	11.19	10.63	....	61.92	3.97
466.	H. O. feed	9.40	3.53	13.05	9.86	38.5	60.31	3.85
467.	H. O. feed	9.28	3.41	9.19	10.23	39.0	63.54	4.35
540.	H. O. feed	8.55	3.32	12.50	10.87	38.3	61.21	3.55
	Average	9.08	3.42	11.58	10.32	38.6	61.68	3.92
419.	Quaker oat feed	8.10	5.17	11.31	16.33	26.5	55.40	3.69
473.	Quaker oat feed	6.20	5.33	10.69	17.29	25.6	57.08	3.41
507.	Quaker oat feed	7.96	4.85	9.31	16.66	29.5	58.23	2.99
681.	Quaker oat feed	7.23	5.30	11.50	15.27	....	56.57	4.13
	Average	7.37	5.16	10.70	16.39	27.2	56.82	3.56
503.	Victor feed	9.49	3.43	8.56	10.78	38.9	63.63	4.11
654.	Victor corn and oats....	9.17	3.43	8.25	11.56	....	64.05	3.54
668.	Victor corn and oats....	8.94	3.60	7.63	12.20	....	64.60	3.03
	Average	9.20	3.49	8.15	11.51	....	64.09	3.56
432.	Corn and oat feed	8.18	3.35	9.37	9.84	42.1	64.93	4.33
544.	Corn and oat feed	9.91	3.08	7.56	11.71	35.2	64.28	3.46
	Average	9.04	3.22	8.46	10.78	38.6	64.61	3.89
444.	Chop feed	9.92	2.73	8.44	6.56	44.1	68.25	4.10
447.	Chop feed	9.14	3.57	8.50	10.97	38.9	63.92	3.90
472.	Chop feed	11.03	2.65	14.19	6.76	37.9	61.75	3.62

ANALYSES OF SAMPLES — *Continued.*

Station number.		Water.	Ash.	Protein.	Fiber.	Starch and sugar.	Total nitrogen-free extract.	Fat.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
480.	Chop feed	13.04	2.17	11.38	4.72	42.5	65.31	3.38
482.	Chop feed	10.99	2.06	10.44	5.57	40.6	66.56	4.38
492.	Chop feed	9.11	2.93	7.81	8.84	43.7	67.92	3.39
497.	Chop feed	11.30	1.92	9.81	5.51	51.2	66.90	4.56
548.	Chop feed	8.97	2.85	8.63	8.13	42.8	68.07	3.35
677.	Chop feed	11.38	3.32	6.56	12.82	....	64.63	1.29
695.	Chop feed	9.92	3.59	7.19	14.16	....	62.46	2.68
697.	Chop feed	9.07	3.57	8.63	12.18	....	62.80	3.75
703.	Chop feed	10.14	1.19	8.13	11.44	....	61.98	5.12
704.	Chop feed	8.60	3.07	8.56	9.71	....	66.62	3.44
542.	Chop feed oats	5.34	6.43	4.56	29.74	8.7	52.26	1.67
	Average of chop feed, excluding last analysis	10.06	2.81	9.23	9.27	42.7	64.84	3.79
648.	H. O. defi. feed	8.54	3.91	8.50	14.78	....	61.25	3.02
554.	X oat feed	6.72	6.15	6.31	24.31	15.0	54.02	2.49
657.	Schumaker's stock food, corn, oats and barley..	8.83	3.41	12.69	7.53	....	62.48	5.06
420.	Corn, oat and barley feed	9.09	1.47	11.19	9.93	36.7	63.95	4.37
650.	Wheat feed	9.22	4.04	11.00	16.56	....	56.09	3.09

It is important to properly interpret the facts displayed in the above tables in their practical relations to the stockman. It is to be noted in the first place that the prices of these various mixed feeds are in many cases fully equal to what a mixture of whole corn and oats would have cost at the time the samples were taken. This being so, it is fair to inquire whether the by-product combinations of the class we are discussing are equal in value to the entire cereal grains. The principal fact to be considered in this connection is that nearly all of the feeds mentioned above contain a generous proportion of oat offals, largely hulls. This is shown in two ways, viz.: by the high proportion of woody fiber and by the low protein content. Oats contain more fiber than any other

cereal grain except buckwheat, the average percentage in thirty samples of American oats being 9.5 per ct.

In 26 cases out of 34 the fiber content of these mixtures, as shown above, is larger than that in average oats and in 16 instances it ranges between 11.0 and 29.7 per ct. Moreover, a majority of these feeds contain quite a proportion of corn, or perhaps hominy waste, material, which has a very low fiber content, averaging not over 2 per ct. It is clear that a mixture of the entire grains of corn and oats which does not carry less fiber than the oats, is impossible, and inversely it is equally plain that combinations of corn and of oat offals with as large and generally much larger, percentage of fiber than is found in pure oats must contain more oat hulls than belong with the oat kernels present, That this is true of many of these feeding stuff mixtures is shown by a mere mechanical examination without resorting to a chemical analysis. Some of them must contain not less than 50 lbs. of oat hulls per hundred pounds. The low proportion of protein is also evidence of a convincing character. In 20 out of the 34 samples, the protein content is below what would ever be the case with a mixture of whole corn and oats, a condition which is brought about by the small proportion of protein in the oat hulls present.

In certain brands an amount of some highly nitrogenous feeding stuff like cotton-seed meal or gluten meal is found, the object of its use being to bring up the protein content to the standard of wheat bran. This certainly improves the feed, but at the same time the presence of high quality ingredients adds nothing to the value of the inferior constituents. Grinding corn with oat hulls, for instance, may not injure the corn but it does not improve the hulls. They are still hulls and retain all their characteristics as a feeding stuff.

In order to ascertain the effect upon digestibility of introducing oat feed into a feeding stuff mixture, an experiment has been conducted at this Station with sheep, using as the experimental feed-

ing stuff an oat feed sold in the State of New York. The results were as follows:

DIGESTION EXPERIMENT WITH OAT FEED.

ANIMALS.	Digestion Coefficients.					
	Dry matter.	Organic matter.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct
Sheep No. 3	59	60	81	37	61	92
Sheep No. 4	57	59	84	31	60	92
Average for oat feed	58	59.5	82.5	33	60.5	92
Average for whole oats, German trials	...	71.4	78	25.6	76.8	83.5
Average for maize kernels	...	90.7	76	58	93.3	85.5

The organic matter represents the total amount (ash excepted) of nutritive compounds which are utilized by an animal in maintaining and building the body and it appears that the whole oats furnish about 12 lbs. and maize 31 lbs. more of this per hundred than the oat feed. Besides, the material coming from the entire grains is of better quality, being made up more largely of protein and the easily digestible carbohydrates.

THE CARBOHYDRATES OF MIXED FEEDS AND OTHER FEEDING STUFFS.

The superiority of the dry matter of the cereal grains over that of the coarse fodders is generally recognized. This fact is due to two causes, viz: (1) The greater extent and (2) the greater ease of digestion of the grains as compared with the fodders. In this connection the carbohydrates are of first importance, in point of quantity at least. These compounds differ among themselves in their digestibility to a marked extent. The sugars and starches, under normal conditions are promptly and completely digested, while the gums, fiber and other less well known substances are

only partially dissolved in the digestive juices. It follows, then, other things being equal, that the larger the proportion of starch and sugar in the nitrogen-free extract of a feeding stuff the more completely is it digested.

It also follows that when any manufacturing or other process reduces the proportion of sugars and starch in any grain or other material, the digestibility, and consequently the nutritive value of its non-nitrogenous part, is diminished. We have good reason for believing too, that the net value of that which is digested is less than would be the case if the proportion of starch and sugar had not been reduced.

While the digestion products of fiber and gums are undoubtedly oxidized quite fully and perhaps furnish to the animal their full calorimetric value (except a small proportion of expiratory methan supposed to come from the fiber) the elaborate researches of Zuntz leave little doubt that their net value is less than digested sugars and starch. This is because the work of mastication and digestion of the former is greater.

As a matter of illustration we may refer to the great superiority of corn meal over timothy hay in point of digestibility, the explanation of which is in accordance with the facts just stated. The nitrogen-free extract of maize is mostly starch, the accompanying fiber being insignificant in amount whereas in timothy hay there is found a small proportion of sugars and starch, while gums, fiber and other less digestible compounds are abundant.

Moreover, because of the more resistant qualities of the hay to mastication and propulsion along the alimentary canal, it costs more to digest it than is the case with maize and other grains. Practice recognizes these facts in its estimate of the grains as against the fodders.

The point of this discussion will be seen when we come to consider the figures in the following table.

CARBOHYDRATE RELATIONS IN DRY MATTER OF SEVERAL FEEDING STUFFS.

	Sugars and starch.	Total nitrogen-free extract.	Sugars and starch in nitrogen-free extract.	Digestibility of the nitrogen-free extract.
The Oil Meals:	Per ct.	Per ct.	Per ct.	Per ct.
Cotton-seed meal	16	27.9	57.4	50
Linseed meal, O. P.	13.2	39.2	33.7	78
Linseed meal, N. P.	20.8	40.8	51	84
The Gluten Products:				
Gluten meal	38.2	49.8	76.7	93
Buffalo gluten feed	27.3	58.3	46.8	84
Davenport gluten feed	29.8	60.9	48.9	..
Diamond gluten feed	31.6	61.6	51.3	..
Joliet gluten feed	34	66	51.5	..
Peoria gluten feed	28.9	59.8	48.3	90
Malt sprouts	23.1	49.6	46.6	69
Buckwheat middlings	27.3	48.3	56.5	..
Wheat bran	23.6	60.5	39	69
Wheat middlings	38.8	64.2	60.4	85
Hominy feeds	50.1	72.7	68.9	..
H. O. dairy feed	34.6	60.4	57.3	..
Oat feed	29.4	61.5	47.8	60
Victor feed	43	70.3	61.2	..
Chop feeds	47.5	73.5	64.6	..
X oat feed	16.1	57.9	27.8	..
Wheat, entire grain, Stone	57.9	77.7	74.6	..
Wheat, entire grain, Wiley	72.5	78.5	92.4	..
Maize, entire grain, Stone	66	78	84.6	93
Oats, entire grain, Wiley	50.9	66.3	76.8	83
Mixture, maize and oats, equal parts	58.4	72.1	81	..

Many of the materials mentioned above when compared with the grains from which they are derived show a depletion of sugars and starch and a corresponding relative increase in the nitrogen-free extract of the less valuable compounds. This is especially true of the wheat offals, the gluten feeds and the oat feed mixtures. In the case of the one sample of gluten meal examined the starch still constituted a large proportion of the nitrogen-free extract. The chop feeds and other similar combinations contain as a rule quite a proportion of corn, that furnishes nearly all the starch which is found in these mixtures. Such materials as the X Oat Feed and

oat chop No. 542 have in them but little starch, these being nearly pure oat offals.

These facts are in harmony with the outcome of digestion experiments, from which we learn that the nitrogen-free extract of the whole grains is much more digestible than that of most of the manufacturing wastes which come from them, as can be seen by the figures in the right hand column of the above table.

Some "mixed feeds" apparently are compounded and advertised on the assumption that feeding stuffs are to be compared in value solely on the basis of their percentage of protein and fat. This is a false basis. The quality of the accompanying carbohydrates must always be considered. For instance it would not be difficult to simulate the composition of corn meal or of wheat middlings by mixing oat hulls with some of the old style linseed meal, adding a little crushed linseed to make up the deficiency of fat. But would the mixture equal corn meal in value? By no means. In one case the protein and fat would be associated with woody fiber in large proportion, and in the other case with little else than starch. The net value of the corn meal would be much above that of the mixture as measured by the extent and labor of digestion.

It is quite clear to the writer that those teachers who publish tables or estimates of feeding stuff comparative values based wholly upon the protein content are misleading the agricultural public and furnishing to manufacturers a justification for false claims.

The relation of oat offals to one class of feeding stuffs has been discussed somewhat at length, because it is proper for farmers to understand its significance. They have a right to know the nature and value of what they are buying, a statement to which no legitimate trade interest will take exception.

MISCELLANEOUS FEEDING STUFFS.

The succeeding table gives the analyses of a number of materials of some interest.

MISCELLANEOUS FEEDING STUFFS.

Station number.	Sample: Where collected.	Ton selling price.	Station number.	Sample; Where collected.	Ton selling price.
558..	Fayetteville	......	512..	Watertown	$18 00
488..	Syracuse	$12 00	520..	Norwich	24 00
505..	Oswego	12 00	560..	Owego	10 20
532..	Binghamton	15 00	506..	Oswego	.10 bu.
541..	Rochester	12 50	547..	Fair Haven	4 00
651..	Sidney	18 00	725..	Gouverneur	......
691..	Central Bridge	17 00	726..	Jordon	......

ANALYSES OF MISCELLANEOUS FEEDING STUFFS.

Station number.		Water.	Ash.	Protein.	Crude fiber.	Sugar and starch.	Nitrogen-free extract.	Fat.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
558.	Pea meal	10.71	3.45	22.61	13.56	....	48.51	1.16
488.	Malt skimmings	6.16	3.49	15.50	7.93	44.2	64.10	2.82
505.	Malt skimmings	7.24	3.43	13.19	8.41	44.6	65.01	2.72
	Average	6.70	3.46	14.35	8.17	44.4	64.55	2.77
532.	Rye feed	11.68	4.39	15.00	4.99	28.2	60.38	3.56
541.	Rye feed	12.65	2.69	14.13	2.93	39.5	64.66	2.94
651.	Rye feed	10.28	4.03	15.19	5.62	....	61.00	3.88
691.	Rye feed	12.22	3.76	15.56	4.63	....	60.50	3.33
	Average	11.70	3.72	14.97	4.54	33.8	61.82	3.25
512.	Scorched wheat	10.08	1.79	12.13	2.17	55.4	71.93	1.90
520.	Scorched wheat	10.12	1.80	11.94	2.07	59.1	72.28	1.79
720.	Sugar corn feed	9.96	0.93	11.25	11.91	....	60.83	5.12
506.	Starch feed, wet.........	65.7	0.23	4.25	2.57	11.6	23.88	3.37
	Starch feed, air dry.....	3.57	0.67	12.37	7.50	33.8	66.07	9.82
547.	"Gluten" feed, wet....	58.2	0.31	4.99	4.13	11.2	27.62	4.75
	"Gluten" feed, air dry..	1.98	0.75	11.94	9.89	26.8	64.08	11.36
725.	Clover meal for poultry.	6.49	6.13	9.63	28.31	....	46.21	3.23
726.	Clover meal for poultry.	8.90	6.23	10.38	28.49	....	43.18	2.82

Several points connected with the above analyses are worthy of attention.

The malt skimmings are seen to be quite unlike other brewer's residues, in having a low protein content.

Rye feed, about which questions are frequently asked, corresponds quite closely in composition to wheat offals.

Attention is called to the low protein content of certain feeds which are refuses from starch manufacture. These are not unlike corn meal in the proportion of their constituents and should not be confounded with gluten meals and feeds.

The composition of clover hay is not modified by grinding. So long as cut clover hay is fed successfully to poultry the advantage of paying from $20 to $30 or more per ton for having it ground is not clear.

CONDIMENTAL FOODS.

There is found very prevalent in our markets a class of substances bearing the term "food" that are noted chiefly for being sold in small packages at remarkable prices, on the strength of claims which are sometimes startling even in this time of daily miracles as set forth in the advertising columns of our newspapers. These proprietary wonders are usually marvelous both in their nutritive and their healing effects, for if one may believe the statements concerning some of them, they are remarkably loaded with nutritive energy and the diseases they will not cure would be highly interesting to the veterinarian as pathological novelties. It is most surprising to find after being told that the effect of these "foods" is to enrich milk, produce bovine obesity with remarkable rapidity and banish disease, that so far no one of them has been examined that is not made up largely of some common grain product mixed with more or less of the commonest of drugs and other substances having little curative value, nearly all of which of any merit whatever may be found on the pantry shelf or in the horse stable of many farms. It is strange, too, that farmers have not long ago discovered for themselves, if it is true, that when bran or some other common feeding stuff is compounded with the equally common charcoal, salt, sulphur, saltpetre, fenugreek, etc., the nutritive power of the food is greatly enhanced and the drug takes on unheard of curative properties. Nevertheless we are asked to believe that such is the case. No

evidence of the accuracy of these unusual properties is furnished, save the usual list of testimonials, the reliability of which may be judged in the light of the fact that some of the most absurd impositions ever perpetrated on the public have been abundantly approved by similar evidence. Years ago, Lawes & Gilbert condemned patent foods at the prices for which they are sold, and important experiments conducted in recent years have not furnished the least justification of their purchase by stockmen. Farmers may accept with perfect confidence this statement, viz.: that there are no nutritive properties, compounds or influences yet discovered which are not possessed by the common feeding stuffs, neither is it possible to increase for well animals the nutritive effect of protein and carbohydrates by associating with them any compounds or drugs whatever.

As to the medicinal value of condimental foods, it may be safely asserted that well animals, properly fed, need no medicine, and sick animals should receive treatment specifically adapted to their ailments. Universal preventives and curealls of diseases are unknown and are believed in only by those who are ignorantly credulous. More than this, many of the constituents of condimental foods have no recognized curative value.

But notwithstanding all that has been said again and again to the farming public concerning condimental foods, they still find a sale. Not less than fifteen brands have been examined at this Station during the past two years, all of which were found in the New York markets. Their analyses from a food standpoint follow.

SAMPLES OF PATENT FOODS COLLECTED IN NEW YORK DURING 1898 AND 1899.

Station number.	Sample: Where collected.	Price per pound.	Station number.	Sample: Where collected.	Price per pound
445..	Corning	.....	459..	Dansville	$0 13 1-3
446..	Corning	$0 20	460..	Mt. Morris	06 1-4
448..	Hornellsville	05	461..	Mt. Morris	10
450..	Hornellsville	25	462..	Buffalo	50
451..	Hornellsville	07 1-3	485..	....	....
456..	Canisteo	25	502..	....	15
457..	Dansville	18	539..	....	....
458..	Dansville	10 1-2			

ANALYSES OF SAMPLES OF PATENT FOODS.

Station number.		Water.	Ash.	Crude protein.	Crude fiber.	Sugar and starch.	Ether extract.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
445.	Flower city horse and cattle food.	9.27	11.29	14.37	9.70	21.0	5.12
446.	International stock food	8.13	9.92	13.88	5.68	21.9	7.91
448.	Blatchford's calf meal	7.12	5.74	26.13	4.23	22.7	4.56
450.	Nutriotone	6.90	20.17	22.19	4.94	23.5	5.13
451.	Pratts' cattle food	7.25	6.36	14.56	5.78	35.4	7.53
456.	Rochester horse and cattle food.	8.00	8.19	18.44	10.59	21.5	3.61
457.	Anglo-American food for stock..	7.20	13.28	15.50	7.86	25.8	4.85
458.	Climax food	7.24	21.09	9.94	4.14	17.2	22.53*
459.	Colonial stock food	7.28	14.51	9.81	11.99	28.8	2.54
460.	Royal stock food	5.56	44.07	11.25	9.73	13.7	3.52
461.	Baums' horse and stock food....	8.05	10.87	27.81	13.00	9.2	7.75
462.	Chas. Marvin stock food	8.26	5.97	30.94	10.63	18.2	4.28
485.	Triplex stock food	7.10	12.05	15.31	6.31	28.8	5.66
502.	Champion horse and cattle food.	8.99	14.40	10.69	4.74	41.2	4.68
539.	Wilbur's seed meal	7.13	12.16	20.00	8.18	20.9	5.63

In these mixtures were found as the principal constituent some common feeding stuff like bran or other wheat offals, corn offals, linseed meal, and so on. The special ingredients added ostensibly for medicinal effect, were found to include charcoal, fenugreek, gentian, sulphur, salt, saltpeter, sodium sulphate, iron compounds and pepper.

Particular attention is called to the prices at which these "foods" are sold. The range is from \$100 to \$500 per ton, which is at least from \$70 to \$470 per ton more than the materials are worth for food purposes. It may be claimed, as some of the manufacturers urge, that these mixtures should be regarded as medicines. Even if this is true the farmer who wishes to administer any of these common substances to his animals can do so at a small fraction of their cost in condimental foods by purchasing them as drugs and then mixing them with the grain ration as he wishes. For the promoters of these mixtures to claim that they have any knowledge of compounds and compounding not common to veterinary medicine is charlatanism in its most offensive form.

Blatchford's calf meal is advertised as a food of great value.

* Mostly sulphur.

Director Woods of the Maine Station gave this product a careful examination and his report concerning it includes the following statements.

"These goods were sent to an expert on food mixtures and adulterations at the Connecticut Experiment Station who reports as follows: 'I have examined Blatchford's calf meal under the microscope and find it contains linseed meal, some product from the wheat kernel, some product from the bean kernel and a little fenugreek. The linseed meal appears to be the chief constituent. The wheat product is bran, middlings or some similar product consisting of starchy matter mixed with more or less of the seed coats. Bean bran was present in considerable amount and more or less of the starchy matter.'

"In a letter just at hand from Mr. J. Barwell, the proprietor of these goods, he says: 'Regarding the ingredients, I cannot give you the exact constituents of it, but I may say that it is composed mostly of locust bean meal with leguminous seeds such as lentils, etc., and oleaginous seeds such as flax-seed, fenugreek and anise seed, all cleaned, hulled and ground together and thoroughly well cooked. There is no cheap mill food and no low grade feed enters into this composition. I am prepared to go into any court in the United States and make an affidavit that there is no farmer in the United States that can compound Blatchford's calf meal for less than $3.50 per hundred.'

"Locust bean meal which Mr. Barwell claims to be the chief constituent of Blatchford's calf meal is practically not used in this country as a cattle feed. The average of ten English and German analyses show it to carry: Water, 14.96 per ct.; ash, 2.53 per ct.; protein, 5.86 per ct.; crude fiber, 6.39 per ct.; nitrogen-free-extract, 68.98 per ct.; fat, 1.28 per ct.

"It is evident from the chemical analyses that locust bean meal can not be the chief constituent of Blatchford's calf meal, but that the microscopist is correct that linseed meal is the chief constituent. Locust bean meal has only six per cent of protein and in order to make a mixture carrying from twenty-six to thirty-three per ct.

of protein it would be necessary to add large quantities of goods like linseed meal rich in protein. As seen from the analyses Blatchford's calf meal has a feeding value somewhat inferior to old process linseed meal. Whatever it may cost to manufacture, no man who has sufficient intelligence to mix feeds can afford to buy it at anything like the price asked."

In the light of this information the farmers of New York must decide whether they can afford to pay at the rate of $100 per ton for materials no more valuable than those which are generally offered in our markets at ordinary prices. Special mention is made of this feed because it is sold for distinctively food purposes and because, prices considered, it perhaps does the farmer's pocket-book as little harm as any other food mentioned in the above list, and less than all excepting No. 462. At the same time it typifies all those efforts here discussed of mixing common materials and selling them under extraordinary names at extraordinary prices.

CONCENTRATED FEEDING STUFFS LAW.

LAWS OF NEW YORK, CHAP. 510.

AN ACT to amend the agricultural law, regulating the sale and analysis of concentrated feeding stuffs.

Became a law May 3, 1899, with the approval of the Governor. Passed, three-fifths being present.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. Chapter three hundred and thirty-eight of the laws of eighteen hundred and ninety-three, entitled, "An act in relation to agriculture, constituting articles one, two, three, four and five of chapter thirty-three of the general laws," is hereby amended by adding at the end thereof a new article to be known as article nine, and to read as follows:

ARTICLE IX.

SALE AND ANALYSIS OF CONCENTRATED COMMERCIAL FEEDING STUFFS.

Section 120. Term "concentrated commercial feeding stuffs" defined.
121. Statements to be attached to packages; contents; analysis.
122. Statements to be filed with director of agricultural experiment station; to be accompanied by sample.
123. License fee.
124. Analysis to be made by director of experiment station; samples to be taken for analysis.
125. Penalty for violation of article.
126. Sale of adulterated meal or ground grains; penalty.
127. Violation to be reported to the commissioner of agriculture.

§ 120. Term "concentrated commercial feeding stuff" defined. — The term "concentrated commercial feeding stuffs" as used in this article shall include linseed meals, cottonseed meals, pea-meals, cocoanut meals, gluten meals, gluten feeds, maize feeds, starch feeds, sugar feeds, dried brewer's grains, malt sprouts, hominy feeds, cerealine feeds, rice meals, oat feeds, corn and oat chops, ground beef or fish scraps, mixed feeds, and all other material of similar nature; but shall not include hays and straws, the whole seeds nor the unmixed meals made directly from the entire grains of wheat, rye, barley, oats, Indian corn, buckwheat, and broom corn. Neither shall it include wheat, rye and buckwheat brans or middlings, not mixed with other substances, but sold separately, as distinct articles of commerce, nor pure grains ground together.

§ 121. Statements to be attached to packages; contents; analysis. — Every manufacturer, company or person who shall sell, offer or expose for sale or for distribution in this state any concentrated

commercial feeding stuff, used for feeding farm live stock, shall furnish with each car or other amount shipped in bulk and shall affix to every package of such feeding stuff in a conspicuous place on the outside thereof, a plainly printed statement clearly and truly certifying the number of net pounds in the package sold or offered for sale, the name or trade mark under which the article is sold, the name of the manufacturer or shipper, the place of manufacture, the place of business and a chemical analysis stating the percentages it contains of crude protein, allowing one per centum of nitrogen to equal six and one-fourth per centum of protein, and of crude fat, both constitutents to be determined by the methods prescribed by the director of the New York Agricultural Experiment Station. Whenever any feeding stuff is sold at retail in bulk or in packages belonging to the purchaser, the agent or dealer, upon request of the purchaser, shall furnish to him the certified statement named in this section.

§ 122. Statements to be filed with director of agricultural experiment station; to be accompanied by sample.— Before any manufacturer, company or person shall sell, offer or expose for sale in this state any concentrated commercial feeding stuffs, he or they shall for each and every feeding stuff bearing a distinguishing name or trade mark, file annually during the month of December with the director of the New York Agricultural Experiment Station a certified copy of the statement specified in the preceding section, said certified copy to be accompanied, when the director shall so request, by a sealed glass jar or bottle containing at least one pound of the feeding stuff to be sold or offered for sale, and the company or person furnishing said sample shall thereupon make affidavit that said sample corresponds within reasonable limits to the feeding stuff which it represents, in the percentage of protein and fat which it contains.

§ 123. License fee.— Each manufacturer, importer, agent or seller of any concentrated commercial feeding stuffs, shall pay annually during the month of December to the treasurer of the New York Agricultural Experiment Station a license fee of twenty-

five dollars. Whenever a manufacturer, importer, agent or seller of concentrated commercial feeding stuffs desires at any time to sell such material and has not paid the license fee therefor in the preceding month of December, as required by this section, he shall pay the license fee prescribed herein before making any such sale. The amount of license fees received by such treasurer pursuant to the provisions of this section shall be paid by him to the treasurer of the state of New York. The treasurer of the state of New York shall pay from such amount when duly appropriated the moneys required for the expense incurred in making such inspection required by this section and enforcing the provisions thereof. The board of control of the New York Agricultural Experiment Station shall report annually to the legislature the amount received pursuant to this article, and the expense incurred for salaries, laboratory expenses, chemical supplies, traveling expenses, printing and other necessary matters. Whenever the manufacturer, importer or shipper of concentrated commercial feeding stuffs shall have filed the statement required by section one hundred and twenty-one of this article and paid the license fee as prescribed in this section, no agent or seller of such manufacturer, importer or shipper shall be required to file such statement or pay such fee.

§ 124. Analysis to be made by director of experiment station; samples to be taken for analysis.— The director of the New York Experiment Station shall annually analyze, or cause to be analyzed, at least one sample to be taken in the manner hereinafter prescribed, of every concentrated commercial feeding stuff sold or offered for sale under the provisions of this act. Said director shall cause a sample to be taken, not exceeding two pounds in weight, for said analysis, from any lot or package of such commercial feeding stuff which may be in the possession of any manufacturer, importer, agent or dealer in this state; but said samples shall be drawn in the presence of the parties in interest, or their representatives and taken from a parcel or a number of packages, which shall not be less than ten per centum of the whole lot sampled, and shall be thoroughly mixed, and then divided into equal samples,

and placed in glass vessels, and carefully sealed and a label placed on each, stating the name of the party from whose stock the sample was drawn and the time and place of drawing, and said label shall also be signed by the person taking the sample, and by the party or parties in interest or their representative at the drawing and sealing of said samples; one of said duplicate samples shall be retained by the director and the other by the party whose stock was sampled; and the sample or samples retained by the director shall be for comparison with the certified statement named in section one hundred and twenty-two of this article. The result of the analysis of the sample or samples so procured, together with such additional information as circumstances advise, shall be published in reports or bulletins from time to time.

§ 125. Penalty for violation of article.— Any manufacturer, importer, or person who shall sell, offer or expose for sale or for distribution in this State any concentrated commercial feeding stuff, without complying with the requirements of this article, or any feeding stuff which contains substantially a smaller percentage of constituents than are certified to be contained, shall, on conviction in a court of competent jurisdiction, be fined not more than one hundred dollars for the first offense, and not more than two hundred dollars for each subsequent offense.

§ 126. Adulterated meal or ground grain; penalty.— Any person who shall adulterate any kind of meal or ground grain with milling or manufacturing offals, or other substance whatever, for the purpose of sale, unless the true composition, mixture or adulteration thereof is plainly marked or indicated upon the package containing the same or in which it is offered for sale; or any person who knowingly sells, or offers for sale any meal or ground grain which has been so adulterated unless the true composition, mixture or adulteration is plainly marked or indicated upon the package containing the same, or in which it is offered for sale, shall be fined not less than twenty-five or more than one hundred dollars for each offense.

§ 127. Violation to be reported to the commissioner of agriculture. —Whenever the director becomes cognizant of the violation of any of the provisions of this article, he shall report such violation to the commissioner of agriculture, and said commissioner of agriculture shall prosecute the party or parties thus reported; but it shall be the duty of said commissioner upon thus ascertaining any violation of this article, to forthwith notify the manufacturer, importer or dealer in writing and give him not less than thirty days thereafter in which to comply with the requirements of this article, but there shall be no prosecution in relation to the quality of any concentrated commercial feeding stuff if the same shall be found substantially equivalent to the certified statement named in section one hundred and twenty-two of this article.

§ 2. This act shall take effect December first, eighteen hundred and ninety-nine.

ANIMAL FOOD FOR POULTRY.*

W. P. Wheeler.

SUMMARY.

Of two rations which contained practically the same proportions of the ordinarily considered groups of constituents, but different amounts of mineral matter, one wholly of vegetable origin proved much inferior for growing chicks to the other ration, higher in ash content, containing animal food.

When the deficiency of mineral matter was made good by the addition of bone ash, the vegetable food ration for chicks equalled or somewhat surpassed in efficiency the corresponding ration in which three-eighths of the protein was derived from animal food.

For laying hens the rations containing animal food proved superior to others in which all the organic matter was derived from vegetable sources. The vegetable-food ration supplemented by bone ash proved equally efficient for limited periods.

Rations containing animal food proved very much superior for ducklings to rations of vegetable origin which had, according to the ordinary methods of estimation, practically the same nutritive value. A ration of vegetable food supplemented by bone ash proved much inferior to another ration of similar "composition" in which three-eighths of the protein came from animal food.

INTRODUCTION.

Information about foods is one of the first essentials in poultry keeping. A very important part of this information concerns the necessity or economy of using animal food. The need for data

* Reprint of Bulletin No. 171.

upon this subject has led to a number of feeding experiments at this station.

Aside from the usual increase in cost of food no results have discredited the moderate use of animal food from healthful sources. In general, rations entirely of vegetable origin have proved much less efficient than corresponding rations which contained animal foods. But it appears that the inferiority is due in some instances more to the lack of sufficient mineral matter than to the less efficient forms of the other food constituents.

The data from some of the preliminary feeding trials were published in Bulletin 149. The rations then fed contained equal amounts of protein; but in part of the ration from two-fifths to one-half of the protein was from animal food, while in contrasted rations it was derived mostly from vegetable sources, although some came from milk curd. Subsequent experiments have corroborated the results then obtained and added to their significance by furnishing supplementary and more extended information. In one series rations in which about 19 per ct. of the dry matter and 37 per ct. of the protein came from animal food proved superior to rations containing an equal amount of protein derived entirely from vegetable food. The rations were similar in nutritive ratio but the one in which animal food was used contained more than twice as much mineral matter and somewhat more fat. In another series the deficiency of mineral matter in the one ration was made good by the addition of bone ash, so that the proportions of protein, ash and fat were alike in the contrasted rations. With this addition a ration of vegetable food was as efficient during certain periods for chicks and hens as a ration containing animal food. For ducklings the vegetable-food ration was thus improved but still did not approach in efficiency the animal food ration.

FIRST SERIES OF EXPERIMENTS.

In this series of experiments ten lots of chicks were fed for ten or twelve weeks and four combined lots afterward for either four

or ten weeks, two lots of laying hens were fed for six and one- half months and two lots for seven and one-half months, and two lots of ducklings for ten weeks. Experimental feeding commenced with the chicks and ducklings when they were one week old and continued until they were ten and twelve weeks old. They were all hatched in incubators and reared in brooders. A small outdoor run on bare ground was allowed each lot. Occasionally a chick escaped through the fence into outside flocks where it could not be identified and was dropped from the lot. In a few lots (Lot VII especially) there was considerable loss at one time from sunstroke caused by accidental exposure. Allowance was made for any loss caused by accident, obviously uninfluenced by feeding. The weight of any that died was accounted in the record as loss in live weight when estimating the food cost per pound gain.

RATIONS.

One ration for chicks and hens consisted of wheat, cracked corn, barley, oats and a mixture (No. 1) composed of 14 parts by weight corn meal, 11 parts animal meal, 2 parts each of ground oats, wheat bran and pea meal, and one part each of wheat middlings, O. P. linseed meal, malt sprouts, brewer's grains and gluten meal. The contrasted ration consisted of wheat, barley, oats and a grain mixture (No. 2) composed of 7 parts each of pea meal and wheat bran, 6 parts of O. P. linseed meal, 4 parts of gluten meal, 3 parts each of corn meal and ground oats and 2 parts each of malt sprouts, brewer's grains and wheat middlings. One pound of salt was added to every 360 pounds of each mixture. Each ration for ducklings contained, with one of these mixtures, wheat bran, corn meal and ground oats.

The animal food used in these experiments was the dried and ground animal meal. Dried blood, fresh bone, beef scraps and pork scraps have often been fed at this Station, but owing to the

inferior palatability of some grades of dried blood and the poor keeping qualities or continual variations in composition of different lots of the other foods, they were not so suitable for use in these experiments.

Green alfalfa was fed to all lots. Oyster shells and grit were fed to the hens and sand and coarse grit to the chicks and ducklings.

VALUATION OF FOODS.

In estimating the cost of the foods the same valuations have been assumed, for convenience of comparison, that had been used in the preliminary series of experiments, although they are most of them lower than the present market prices and those that existed during part of the last series of experiments. Wheat bran, wheat middlings, corn meal, malt sprouts and brewer's grains were rated at $13 per ton, pea meal at $13.50, buckwheat middlings at $14.40, ground oats at $16, linseed meal at $20, gluten meal at $23, ground flaxseed, bone ash and animal meal at $40 per ton. Corn was rated at 40 cents per bushel, barley at 39 cents, oats at 26 cents, and wheat at 80 cents. Alfalfa hay was rated at $10 and green alfalfa at $2 per ton.

In these experiments the cost of the ration could only be a secondary consideration; but only ordinary foods were used and the relations between valuations is a natural one, similar to what would generally exist between rations of vegetable and mixed origin. The data in regard to the food cost of growth are therefore important.

The food used in the first series of experiments had the average composition[1] shown in the accompanying table.

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[1] Most of the analyses of foods used in these experiments were made by Mr. J. A. Le Clerc. Some ash analyses were made by Mr. W. H. Andrews. Very much of the credit is due to Mr. P. F. O'Neill; for the successful control of the experiments has been dependent on his careful and skillful management.

Crop Production.

TABLE I.— COMPOSITION OF FOODS USED IN FIRST SERIES OF POULTRY FEEDING EXPERIMENTS.

FOOD.	Water.	Ash.	Protein.	Albuminoids.	Fiber.	Nitrogen-free extract.	Fats (ether extract.)
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Mixture 1	11.8	13.6	19.8	17.4	3.7	45.4	5.7
Mixture 2	13.9	3.9	19.9	18.6	6.5	52.9	3.8
Animal meal	7.3	38.7	33.8	26.2	1.7	7.7	10.8
Corn meal	14.8	1.4	8.7	8.7	1.6	70.1	3.4
Wheat bran	14.7	6.3	15.7	14.7	9.1	49.4	4.8
Ground oats	15.9	2.8	12.6	12.4	9.5	54.8	4.4
Corn	15.1	1.4	9.5	9.4	1.4	68.9	3.7
Wheat	15.7	1.8	10.6	9.7	2.3	67.9	1.7
Oats	15.1	3.1	12.2	12.1	10.1	54.9	4.6
Barley	14.1	2.6	10.8	10.4	4.6	65.9	2.0
Alfalfa, green	78.1	1.9	4.2	....	5.8	9.1	.9
Alfalfa hay	16.0	9.1	16.8	....	23.2	32.6	2.3

EXPERIMENT WITH CHICKS.

In two lots of this series of experiments the chicks were two weeks old when the experiment began, in all the others one week old. Lots I, III, V, VII and IX were fed the ration containing animal meal and Lots II, IV, VI, VIII and X were fed the contrasted ration. At the start Lot I was similar in every way to Lot II. The same was true of Lots III and IV, V and VI, VII, and VIII, and IX and X. After the first four lots had been fed for eight weeks the cockerels were removed and a number of pullets from Lots I and III were fed for ten weeks in comparison with an equal number from Lots II and IV. Later, chicks from Lots V and VII after removal of many of the cockerels were fed together in comparison with others from Lots VI and VIII.

The chicks in Lots I and II were Leghorns, those in III and IV mostly Leghorns with a few Wyandottes. Half of those in Lots V, VI, VII and VIII were Leghorns and half Wyandottes and crosses. In Lots IX and X somewhat more than half the chicks were Wyandottes and crosses and the remainder Leghorns.

The records of feeding and statements of the results follow in tabulated form, the averages in most cases being for 14-day periods.

TABLE II.—CHICKS FED ANIMAL FOOD. LOT I.

Forty per cent. of the Protein in the Ration from Animal Food.

Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Average per fowl for period: Mixture I.	Corn.	Wheat.	Barley.	Oats.	Green alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
14	2	.3	41	5.1	1.2	1.2	.5	.5	.7	1.4	.8	.4	1:4.2	.6	.5	.04	3.2	2.7	2.7	2.3
14	4	.5	41	8.1	2.3	2.0	1.0	1.0	1.7	2.3	1.3	.7	1:4.4	1.2	.9	.07	3.1	2.3	4.7	4.1
14	6	.9	41	12.8	2.6	2.5	1.3	1.2	2.4	3.4	1.9	1.0	1:4.1	1.6	1.3	.09	5.9	1.9	3.6	3.1
14	8	1.2	41	17.1	3.3	3.1	1.5	1.9	3.1	4.6	2.6	1.3	1:4.1	2.1	1.7	.12	5.3	1.6	5.3	4.6

TABLE III.— CHICKS FED VEGETABLE FOOD. LOT II.

A Ration of Vegetable Food Only.

Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Average per fowl for period. Mixture 2.	Corn.	Wheat.	Barley.	Oats.	Green alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
14	2	.3	42	4.4	...	1.4	.9	.4	.7	1.2	.2	.2	1:4.3	.6	.5	.03	2.0	2.3	3.2	3.1
14	4	.5	41	8.3	...	3.0	1.9	1.0	1.7	2.4	.5	.5	1:4.4	1.1	.9	.06	3.5	2.2	3.7	3.5
14	6	.8	41	12.1	...	3:6	2.5	1.2	2.4	3.3	.7	.6	1:4.3	1.6	1.2	.08	4.7	1.9	3.7	3.7
14	8	1.0	41	13.4	...	4.3	2.9	1.5	3.1	3.7	.8	.7	1:4.3	1.8	1.4	.09	2.5	1.6	7.8	7.7

TABLE IV.— CHICKS FED ANIMAL FOOD. LOT III.

Thirty-eight per ct. of the Protein in the Ration from Animal Food.

Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Average per fowl for period. Mixture 1.	Corn.	Wheat.	Barley.	Oats.	Green alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
14	1	.3	23	6.3	1.2	1.3	.5	.6	.6	1.6	.9	.5	1:4.1	.7	.6	.05	2.8	1.6	3.7	3.0
14	3	.6	22	11.0	2.5	2.4	1.1	1.3	1.7	3.0	1.7	.9	1:4.2	1.4	1.2	.08	5.3	2.6	3.6	2.9
14	5	.9	22	16.1	3.7	3.8	2.1	1.9	2.3	4.5	2.5	1.3	1:4.3	2.1	1.7	.13	4.1	2.3	6.9	6.0
14	7	1.2	22	20.6	4.4	4.4	2.2	2.2	3.5	5.6	3.1	1.6	1:4.2	2.7	2.1	.15	5.9	2.1	5.9	5.1
*14	10.5	1.8	33	23.4	5.7	5.7	2.6	2.8	8.5	6.8	3.7	1.9	1:4.3	3.5	2.6	.18	7.1	1.6	5.8	5.2
*28	12.5	2.4	33	42.4	8.7	9.2	3.9	4.6	17.0	11.9	6.6	3.3	1:4.2	3.1	2.3	.16	9.2	1.1	7.9	6.4
*28	16.5	3.3	32	67.1	14.8	14.8	7.4	7.4	17.5	18.7	10.4	5.3	1:4.2	4.6	3.6	.26	13.1	1.3	8.9	7.7

* Pullets from Lots I and III, after removal of cockerels.

TABLE V.— CHICKS FED VEGETABLE FOOD. LOT IV.

A Ration of Vegetable Food Only.

Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Average per fowl for period. Mixture 2.	Corn.	Wheat.	Barley.	Oats.	Green alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
14	1	.3	23	4.8	...	1.7	1.3	.6	.6	1.4	.3	.3	1:4.4	.6	.5	.03	2.8	2.6	2.7	2.6
14	3	.6	23	8.4	...	3.3	2.0	1.1	1.5	2.4	.5	.5	1:4.2	1.2	.9	.06	4.8	2.1	2.8	2.7
14	5	.9	23	15.3	...	4.1	2.6	1.3	2.1	4.0	.8	.8	1:4.5	1.8	1.5	.09	4.7	2.0	4.4	4.4
14	7	1.1	23	14.1	...	5.9	3.8	2.0	3.4	4.2	.9	.8	1:4.4	2.1	1.6	.11	2.4	1.6	9.9	9.7
*14	10.5	1.3	33	17.7	...	6.6	4.0	2.4	8.5	5.3	1.1	1.1	1:4.4	2.8	2.0	.13	2.8	1.7	10.1	9.0
*28	12.5	1.7	33	33.8	...	10.2	7.0	3.3	17.0	9.7	2.1	1.9	1:4.3	2.5	1.8	.11	6.5	1.2	7.6	7.8
*28	16.5	2.3	33	52.2	...	18.6	11.9	6.2	17.0	15.1	3.2	3.0	1:4.4	3.8	2.9	.18	9.9	1.4	8.2	8.1

* Pullets from Lots II and IV, after removal of cockerels.

TABLE VI.— CHICKS FED ANIMAL FOOD. LOT V.

Thirty-seven per c.t. of the Protein in the Ration from Animal Food.

Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Average per fowl for period. Mixture 1.	Corn.	Wheat.	Barley.	Oats.	Green alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
14	1	.3	44	4.6	.8	.9	.5	.5	.9	1.2	.7	.3	1:4.1	.6	.5	.03	2.3	2.3	3.5	2.9
14	3	.4	41	7.4	1.6	1.8	.9	.9	1.6	2.1	1.1	.6	1:4.2	1.0	.8	.06	2.8	2.3	6.4	4.0
14	5	.7	38	10.9	2.3	2.7	1.0	1.2	2.8	3.0	1.7	.9	1:4.2	1.5	1.2	.08	4.3	2.1	4.4	3.8
14	7	1.0	35	15.0	3.2	3.1	1.9	1.6	5.2	4.2	2.3	1.2	1:4.2	2.1	1.6	.11	4.1	1.9	7.1	5.6
21	9	1.6	35	28.9	6.1	6.9	3.7	3.7	9.6	8.3	4.5	2.3	1:4.2	2.8	2.1	.15	10.0	1.7	5.1	4.5

TABLE VII.—CHICKS FED VEGETABLE FOOD. LOT VI.

A Ration of Vegetable Food Only.

Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Average per fowl for period. Mixture 2.	Corn.	Wheat.	Barley.	Oats.	Green alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
14	1	.3	43	4.1	...	1.3	.8	.4	1.0	1.1	.2	.2	1:4.3	.5	.4	.03	2.3	2.1	2.7	2.6
14	3	.4	42	7.6	...	2.4	1.6	.7	1.6	2.1	.4	.4	1:4.3	1.0	.8	.05	2.3	2.3	5.6	4.9
14	5	.5	40	8.6	...	2.9	1.9	1.1	2.7	2.5	.5	.5	1:4.4	1.2	.9	.06	1.4	2.1	9.9	9.0
14	7	.8	40	10.5	...	3.5	2.4	1.3	4.6	3.1	.7	.6	1:4.3	1.6	1.2	.07	4.9	1.8	3.3	3.3
21	9	1.1	40	21.9	...	8.0	5.4	2.8	8.4	6.5	1.4	1.3	1:4.4	2.2	1.7	.11	5.2	1.7	7.0	6.7

TABLE VIII.— CHICKS FED ANIMAL FOOD. LOT VII.

Thirty-six per ct. of the Protein in the Ration from Animal Food.

				Average per fowl for period.															
Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Mixture 1.	Corn.	Wheat.	Barley.	Oats.	Green alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
14	1	.3	44	4.7	.9	.9	.5	.5	1.3	1.3	.7	.4	1:4.1	.6	.5	.03	2.3	2.5	3.6	3.0
14	3	.5	41	7.2	1.7	1.7	.9	.8	2.0	2.1	1.1	.6	1:4.3	1.0	.8	.06	2.7	2.0	3.6	4.2
14	5	.7	39	11.0	2.9	2.4	1.1	1.3	2.9	3.1	1.7	.9	1:4.2	1.5	1.2	.08	3.8	2.0	5.1	4.5
14	7	.9	31	14.1	2.5	3.2	1.7	1.4	5.3	4.0	2.2	1.1	1:4.2	2.0	1.5	.11	3.9	1.9	6.5	5.4
21	9	1.5	29	24.8	5.7	5.7	2.8	3.0	8.7	7.1	3.9	2.0	1:4.2	2.4	1.8	.13	8.9	1.5	4.9	4.3
*28	12	2.7	47	37.9	10.3	9.4	4.6	4.6	11.2	11.0	5.9	3.1	1:4.3	2.8	2.2	.15	17.3	1.0	3.9	3.5
†28	..	3.1	56	54.8	12.0	12.1	6.0	6.0	10.0	15.1	8.4	4.3	1:4.2	3.6	2.9	.21	5.8	1.0	16.0	13.9

* Combined Lots V and VII, after removal of the largest cockerels.

† Pullets from Lots I, III, V, and VII.

TABLE IX.— CHICKS FED VEGETABLE FOOD. LOT VIII.

A Ration of Vegetable Food Only.

				Average per fowl for period.															
Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Mixture 2.	Wheat.	Barley.	Oats.	Green alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Oz	Cts	Lbs.
14	1	.3	44	4.0	1.4	.9	.4	1.3	1.1	.2	.2	1:4.3	.6	.4	.03	2.4	2.2	2.6	2.5
14	3	.4	44	6.5	2.1	1.2	.6	1.9	1.8	.4	.3	1:4.3	.9	.7	.04	2.6	1.9	3.7	3.6
14	5	.7	42	8.0	2.7	2.0	.9	2.7	2.3	.5	.5	1:4.4	1.2	.9	.05	3.1	1.6	4.1	4.0
14	7	.8	39	11.0	3.7	2.4	1.2	4.3	3.2	.7	.6	1:4.3	1.6	1.2	.07	2.7	1.6	7.7	6.2
21	9	1.1	37	20.1	7.6	4.6	2.5	6.9	5.9	1.2	1.2	1:4.4	2.0	1.5	.09	4.1	1.6	8.3	7.7
*28	12	1.7	53	33.3	9.5	6.6	3.3	9.9	9.2	1.9	1.8	1:4.2	2.2	1.7	.11	11.2	1.3	4.3	4.3
†28	..	2.9	64	38.9	12.7	8.1	4.2	8.8	10.8	2.3	2.1	1:4.3	2.6	2.0	.13	11.4	.8	5.0	5.0

* Combined Lots VI and VIII, after removal of the largest cockerels.
† Pullets from Lots II, IV, VI, and VIII.

TABLE X.— CHICKS FED ANIMAL FOOD. LOT IX.

Thirty-seven per ct. of the Protein in the Ration from Animal Food.

Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Average per fowl for period.													Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
				Mixture 1.	Corn.	Wheat.	Barley.	Oats.	Green alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.				
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
14	1	.3	51	4.5	.9	.8	.4	.4	1.1	1.2	.7	.3	1:4.1	.6	.5	.03	1.8	2.3	4.3	3.5
14	3	.4	46	5.7	1.5	1.6	.8	.8	1.8	1.7	.9	.5	1:4.4	.9	.7	.05	2.3	1.9	4.6	3.6
14	5	.7	44	9.2	1.8	1.8	.9	.9	2.6	2.5	1.4	.7	1:4.1	1.2	.9	.07	3.7	1.7	4.1	3.6
14	7	.9	43	11.4	3.0	2.8	1.6	1.6	3.9	3.4	1.8	.9	1:4.3	1.7	1.3	.09	3.5	1.7	7.5	5.4
21	9	1.4	40	24.3	5.3	5.1	2.6	2.6	7.4	6.8	3.8	1.9	1:4.2	2.3	1.7	.12	7.2	1.5	6.2	5.0
*28	12	2.1	24	49.8	10.3	10.7	5.0	5.1	11.7	13.6	7.6	3.8	1:4.2	3.3	2.6	.18	14.3	1.6	5.8	5.1
*28	..	3.1	24	61.5	13.3	14.0	6.6	6.7	11.7	16.9	9.4	4.8	1:4.2	4.1	3.3	.23	16.1	1.3	6.5	5.6

* Pullets only, after removal of the cockerels.

TABLE XI.— CHICKS FED VEGETABLE FOOD. LOT X.

A Ration of Vegetable Food Only.

Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Average per fowl for period. Mixture 2.	Wheat.	Barley.	Oats.	Green alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
14	1	.2	50	4.6	1.3	.8	.5	1.1	1.3	.3	.2	1:4.2	.6	.5	.03	1.1	3.1	6.5	5.8
14	3	.3	46	5.0	2.2	1.5	.7	1.8	1.5	.3	.3	1:4.5	.8	.6	.04	1.0	2.4	11.3	8.7
14	5	.4	41	7.1	2.0	1.6	.7	2.7	2.0	.4	.4	1:4.3	1.0	.7	.05	2.3	2.1	4.5	4.5
14	7	.5	40	8.4	3.2	2.0	1.0	4.2	2.5	.5	.5	1:4.4	1.3	1.0	.06	1.8	2.1	9.1	7.7
21	9	.8	36	16.0	3.6	3.5	2.0	8.2	4.5	1.0	.9	1:4.2	1.6	1.1	.07	2.9	1.7	10.6	8.0
*28	12	1.4	18	51.0	15.8	11.0	5.0	15.6	14.3	3.0	2.8	1:4.3	3.5	2.7	.16	11.5	2.5	6.5	6.5
*28	..	2.4	18	43.7	21.7	15.8	8.2	15.6	14.3	3.1	2.9	1:4.6	3.7	2.9	.18	15.4	1.5	5.4	5.2

* Pullets only, after removal of the cockerels.

RELATIVE EFFICIENCY OF THE RATIONS FOR CHICKS.

More food was eaten by the chicks having the ration containing animal meal. Calculated on the basis of dry matter the food consumption for Lot I was 12 per ct. greater than for Lot II and the gain in weight 37 per ct. greater. Lot I gained one pound for every 3.6 pounds of dry matter in the food and Lot II gained one pound for every 4.3 pounds of dry matter.

Lot III consumed 24 per ct. more food than Lot IV and made 22 per ct. greater gain in weight. The dry matter in the food consumed for each pound gain in weight was about 4.3 pounds for Lot III and 4.4 pounds for Lot IV.

During the following ten weeks when pullets from Lots I and III were fed in comparison with those from Lots II and IV the consumption of food under the animal meal ration was 26 per ct. greater and the gain made was 53 per ct. greater. The dry matter in the food for each pound gain was 6.6 pounds for Lots I and III and 8.1 pounds for Lots II and IV.

The food consumption of Lot V was 26 per ct. greater than that of Lot VI and the gain in weight 45 per ct. greater. The dry matter in the food for each pound gain in weight was 4.3 pounds for Lot V and 5.0 pounds for Lot VI.

The food consumption of Lot VII was 24 per ct. greater than that of Lot VIII and the gain in weight was 45 per ct. greater. The dry matter in the food for each pound gain in weight was 4.3 pounds for Lot VII and 5.0 pounds for Lot VIII.

During the four weeks that pullets from Lots V and VII were fed in comparison with those from Lots VI and VIII, 37 per ct. more food was consumed under the animal food ration than under the other, and the gain in weight was 54 per ct. greater. The dry matter in the food for each pound gain in weight was 3.5 pounds for the former lots and 4.3 pounds for the latter.

The food consumption of Lot IX was 34 per ct. greater than that of Lot X and the gain in weight more than twice as great. The dry matter in the food for each pound gain in weight was

4.4 pounds for Lot IX and 6.8 pounds for Lot X. During four weeks after the cockerels were removed Lot X consumed about 5 per ct. more food than Lot IX but the latter made 24 per ct. greater gain in weight. The dry matter in the food for each pound gain in weight was 5.1 pounds for Lot IX and 6.5 pounds for Lot X. During the following four weeks about 14 per ct. more food was eaten by Lot IX and only about 4 per ct. greater gain made. The dry matter in the food for each pound gain was about 5.6 pounds for Lot IX and 5.2 pounds for Lot X.

RELATIVE ECONOMY OF THE RATIONS FOR CHICKS.

The cost of food per pound gain in weight for Lot I was 4.1 cents and for Lot II 4.4 cents. For Lot III it was 5.1 cents and for Lot IV 4.5 cents. For the ten weeks with the pullets of the combined lots the cost was 7.7 cents for Lots I and III and 8.3 cents for Lots II and IV.

The food cost of the growth made during the first eleven weeks by Lot V was 4.9 cents and of that made by Lot VI was 5.0 cents. The cost of that made during this time by Lot VII was 5.1 cents and of that made by Lot VIII 5.4 cents. When the pullets from the combined lots were fed for four weeks longer the cost of the gain made by the birds from Lots V and VII was 3.9 cents and of that made by Lots VI and VIII 4.3 cents. After adding to these lots some more matured pullets from the earlier lots, the one combined lot of older birds, from I, III, V and VII, made for a month a slow and costly gain while the others, from II, IV, VI and VIII, whose growth had been slower, still made good gains at moderate cost. The food cost of the gain made by Lot IX was 5.5 cents and of that made by Lot X 8.0 cents per pound.

Owing to the large proportion of Leghorns among the chicks, heavy average weights were never reached, but average weights of one, two and three pounds were always attained much sooner by the chicks having the animal food ration. The first four lots reached the average weight of one-half pound at about the same

time. Lots V and VII averaged one-half pound in weight over a week sooner than Lots VI and VIII and Lot IX over two weeks sooner than Lot X. The average weight of one pound was reached by Lots I and III about a week sooner than by Lots II and IV, the average weight of 1.5 pounds three and one-half weeks sooner, and the average weight of 2 pounds four and four-fifths weeks sooner. The average weight of one pound was reached by Lots V and VII two weeks sooner than by Lots VI and VIII, the average weight of 1.5 pounds over three weeks sooner, the average weight of 2 pounds three and three-fifths weeks sooner, the average weight of 2.5 pounds over four weeks sooner. The average weight of one pound was reached by Lot IX three weeks sooner than by Lot X, the average weight of 1.5 pounds three and four-fifths weeks sooner and the average weight of 2 pounds three weeks sooner.

EXPERIMENT WITH DUCKLINGS.

In the experiment with ducklings the birds in the two lots were all Pekins. Lot A had the rations mentioned on page 77 containing animal food and Lot B the ration of vegetable food. These rations were fed unchanged during the first month. It was then evident that the one ration was very deficient in some respect, for before the end of the fourth week one-half of all the birds in Lot B had died. Animal meal was then added to the ration, otherwise unchanged, for three weeks and then for two weeks longer the original ration was fed. Only one bird died after the first change in the ration. None died in Lot A. After the ten weeks Lot B was fed for five weeks on the ration which had been fed to Lot A, and Lot A was also fed the same ration for three weeks longer. The tabulated data follow:

TABLE XII.—DUCKLINGS FED ANIMAL FOOD. LOT "A."

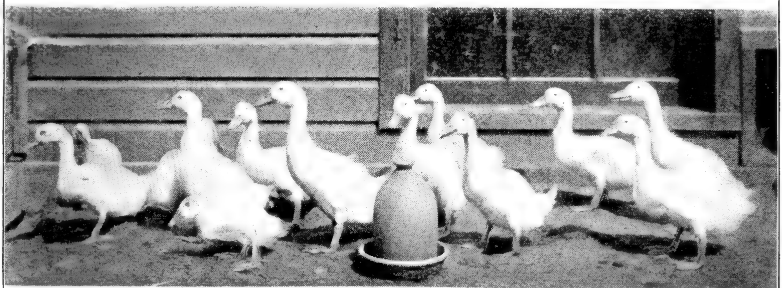
Thirty-seven per ct. of the Protein in the Ration from Animal Food.

Number of days in period.	Average age of ducklings at beginning of period.	Average weight of ducklings at end of period.	Number of fowls.	Average per fowl for period. Mixture 1.	Corn meal.	Wheat bran.	Ground oats.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per fowl during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
7	1	.4	26	5.5	1.4	.2	.5	.8	1.3	.8	.4	1:3.9	1.2	1.0	.07	4.1	3.9	1.8	1.7
7	2	.6	26	5.0	2.0	1.7	1.5	1.6	1.7	.9	.5	1:4.3	1.7	1.3	.08	4.1	2.6	2.2	2.2
7	3	1.1	26	15.7	3.8	2.4	2.1	1.6	4.2	2.4	1.2	1:3.9	3.7	3.0	.20	7.3	3.6	3.2	2.9
7	4	1.6	26	13.3	4.7	3.5	3.4	4.3	4.2	2.3	1.3	1:4.2	4.2	3.2	.20	7.6	2.4	3.0	2.9
7	5	2.1	26	21.4	5.8	3.8	4.0	4.3	6.0	3.4	1.8	1:4.0	5.6	4.5	.29	7.9	2.4	4.2	3.9
7	8	3.0	26	17.2	5.8	4.1	3.8	8.6	5.4	2.9	1.6	1:4.2	5.6	4.1	.26	15.0	1.6	1.9	1.9
7	7	3.5	26	20.4	6.1	4.1	4.4	8.6	6.1	3.4	1.8	1:4.1	6.2	4.6	.30	8.6	1.4	3.9	3.8
7	8	4.2	26	32.0	9.3	6.4	6.2	10.8	9.4	5.3	2.8	1:4.1	9.2	7.0	.45	10.3	1.8	4.9	4.8
7	9	4.9	26	33.2	9.9	5.8	6.7	10.8	9.6	5.4	2.9	1:4.1	9.5	7.2	.47	11.5	1.6	4.6	4.4
21	10	5.9	26	78.2	23.8	16.5	15.9	32.3	23.5	13.1	7.0	1:4.1	7.9	5.9	.37	16.7	1.1	7.6	7.4

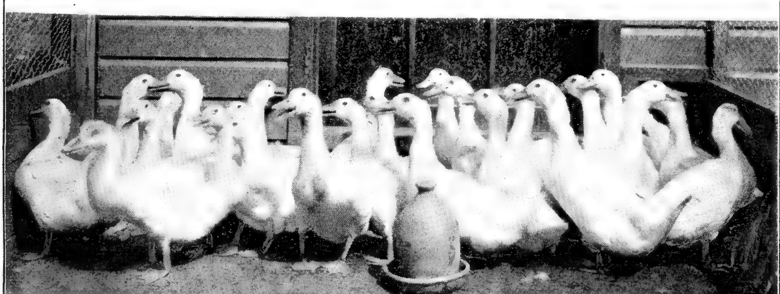
TABLE XIII.—DUCKLINGS FED VEGETABLE FOOD. LOT "B."

A Ration of Vegetable Food Only, for Part of the Time.

				Average per fowl for period.																
Number o days in period.	Average age of ducklings at begini ing of period.	Average weight of ducklings at end of period.	Number of fowls.	Mixture 2.	Co n meal.	Wheat bran.	Ground oats.	Animal meal.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per fowl during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
7	1	.2	27	4.5	.4	.2	.7	...	...	5.0	.2	.2	1:3.9	.8	.7	.04	1.7	4.8	2.6	2.7
7	2	.3	25	3.8	.4	2.3	.6	...	1.7	6.5	.3	.3	1:4.0	1.3	.9	.05	.5	3.7	11.9	8.4
7	3	.4	21	4.8	.5	2.5	1.3	...	2.0	8.3	.4	.4	1:4.1	1.6	1.2	.06	...	3.4	....	7.8
7	4	.4	15	5.8	.3	1.9	1.3	...	4.4	8.9	.5	.4	1:4.0	2.0	1.3	.07	...	3.2	....	14.9
7	5	.7	13	11.4	1.3	3.0	1.5	3.5	5.4	19.3	2.1	1.1	1:3.2	3.7	2.8	.18	3.8	5.0	5.3	4.4
7	6	1.1	13	5.6	.5	4.0	1.6	9.0	6.5	19.8	4.1	1.5	1:2.3	3.9	2.8	.24	5.9	3.1	4.6	3.4
7	7	1.7	13	14.1	1.1	3.0	4.3	4.8	6.5	25.2	2.8	1.5	1:3.2	4.8	3.6	.24	9.0	2.6	3.0	2.8
7	8	2.0	13	23.7	2.5	10.2	3.5	...	8.6	36.2	1.9	1.7	1:4.0	6.9	5.2	.27	4.9	2.8	3.4	7.4
7	9	2.3	13	26.2	2.4	6.8	4.9	...	8.6	36.6	1.8	1.7	1:4.0	7.0	5.2	.28	2.3	2.4	13.3	8.1
				Mixture I.																
35	10	5.5	12	166.4	56.4	47.6	39.4	...	53.7	280.3	28.5	15.9	1:4.2	10.4	8.0	.55	51.2	.1	5.6	5.1



Ducklings of Lot B Nine weeks old.
Average wt. = 2 pounds. Vegetable food only for part of the time. Half of the number died before other food was supplied



Ducklings of Lot A — Nine weeks old.
Average wt. 4.2 pounds. The ration contained animal food. No loss.

Plate I.

RELATIVE EFFICIENCY OF THE RATIONS FOR DUCKLINGS.

The ration containing the animal meal was more freely eaten. Calculated on the basis of dry matter the food consumed by Lot A during the first four weeks was more than twice as much as that by Lot B and the net gain in weight more than ten times as great. For each pound gain in weight there were 2.6 pounds of dry matter in the food for Lot A and 6 pounds for Lot B.

During the following five weeks 40 per ct. more food was consumed by Lot A than by Lot B and the gain in weight made by Lot A was more than twice that made by Lot B. The amount of dry matter in the food for each pound gain was 3.6 pounds for Lot A and 4.8 pounds for Lot B. For the nine weeks over 50 per ct. more food was consumed by Lot A and the total net gain in weight was 2.7 times more than that of Lot B. There were 3.3 pounds of dry matter in the food for Lot A for each pound gain in weight and 5 pounds for Lot B.

When the birds remaining in Lot B were finally changed to the ration that had been fed to Lot A a rapid growth was made and while the gains were not so good as had been previously made by Lot A they were better than those made at this time by the more nearly mature birds in Lot A during three weeks feeding on the same ration. For the five weeks there were 5.1 pounds of dry matter in the food for Lot B for each pound gain in weight and for the three weeks for Lot A 7.4 pounds for each pound gain in weight. It was therefore apparent that while the vegetable food ration greatly retarded the growth up to ten weeks of age and was the cause of great mortality, it did not prevent a rapid and profitable growth by the surviving birds under the better ration. The effect of the first few weeks under the inferior ration could not be entirely overcome however, and the birds from Lot B never reached as satisfactory development as did the others.

RELATIVE ECONOMY OF THE RATIONS FOR DUCKLINGS.

The cost of the food for each pound gain in weight during the first four weeks of the experiment was for Lot A 2.7 cents and

for Lot B 10.1 cents. During the next five weeks the cost was 3.7 cents for Lot A and 5.3 cents for Lot B. For the whole time up to ten weeks of age the food cost per pound gain was 3.4 cents for Lot A and 5.9 cents for Lot B. After Lot B was finally changed to the animal food ration the food cost per pound gain for the five weeks was 5.6 cents. The food cost per pound gain in weight made at this time by Lot A for three weeks after they had reached the average weight of five pounds was 7.6 cents.

At ten weeks of age the ducklings in Lot A averaged 4.9 pounds in weight and those in Lot B 2 pounds. At seven weeks of age those in Lot A averaged 3 pounds in weight and those in Lot B 1.1 pounds. The ducklings in Lot B at five weeks of age, up to which time they had been restricted to the unmodified vegetable food ration averaged but 0.4 pound in weight while those in Lot A averaged four times as heavy. Even with the addition of other food to the vegetable food ration, followed later by a total change, the ducklings in Lot A reached the average weight of one pound three weeks sooner than those in Lot B. The average weight of 2 pounds was reached more than three weeks sooner, the average weight of 3 pounds four and one-half weeks sooner, the average weight of 4 pounds and the average weight of 5 pounds each a month sooner. The average weight of 5 pounds was attained by Lot A when Lot B averaged but little over 2 pounds in weight.

Besides avoiding the serious loss that occurred under the ration entirely of vegetable food, the chief advantage of the animal food ration was in the much more rapid growth and earlier maturity and not so much in the ultimate attainment of greater size.

FEEDING EXPERIMENT WITH HENS.

Of the four lots of laying hens used in this series of experiments, Lots XVII and XVIII were fed the contrasted rations for about seven and one-half months and Lots XIX and XX for about six and one-half months. This included the principal

part of the laying season. Lots XIX and XX were alike at the start, containing equal numbers of two-year-old Wyandotte hens. Lots XVII and XVIII contained equal numbers of Leghorn pullets. The pullets in Lot XVII had been fed from the day they were hatched a ration which contained a large proportion of animal food, while those in Lot XVIII had been grown on a ration of vegetable food supplemented by some skim milk curd. Some of the pullets in both lots had been laying for some time before this experiment began but those in Lot XVII had commenced laying several weeks younger than those in Lot XVIII. The hens in the other two lots had been treated alike until used in this experiment. Lots XVII and XIX were fed the ration containing animal meal described on page 77 and Lots XVIII and XX were fed the contrasted ration.

The accompanying tables give the data averaged for periods generally of four weeks.

TABLE XIV.— YOUNG HENS FED ANIMAL FOOD. LOT XVII.

Thirty-five per ct. of the Protein in the Ration from Animal Food.

Number of days in period.	Average weight per fowl during period.	Number of hens.	Average per fowl for period.															Dry matter in food per day for each pound live weight fed.	Cost of food for each pound of eggs produced.	Dry matter in food for each pound of eggs produced.
			Mixture 1.	Corn.	Wheat.	Barley.	Oats.	Alfalfa hay.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Number of eggs.	Weight of eggs.			
	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs	Ozs	Cts.		Ozs.	Ozs.	Cts.	Lbs.
28	3.4	15	67.2	14.9	14.9	7.5	7.5	11.2	19.9	11.1	5.4	1:4.2	4.4	3.8	.27	11.3	21.1	1.1	5.6	5.1
28	3.6	15	62.0	12.5	13.2	6.3	6.3	7.5	17.6	9.9	4.8	1:4.1	3.9	3.3	.24	12.3	23.5	.9	4.5	4.0
28	3.6	10	54.3	14.2	12.9	7.0	7.0	10.7	16.9	9.2	4.5	1:4.2	3.8	3.3	.22	18.2	34.3	.9	3.0	2.7
28	3.5	10	62.9	13.7	14.0	6.9	6.9	10.7	18.6	10.4	5.0	1:4.2	4.1	3.6	.25	17.9	35.3	1.0	3.1	2.8
								Green.												
28	3.4	10	60.2	12.8	13.0	6.5	6.3	42.7	17.8	9.8	4.9	1:4.2	5.1	3.4	.23	19.2	37.6	1.0	2.8	2.5
35	3.1	10	88.9	20.0	19.5	9.9	10.5	53.3	26.2	14.3	7.3	1:4.2	5.8	4.0	.28	17.3	33.9	1.3	4.6	4.2
21	3.0	10	33.9	7.2	7.4	3.6	3.2	33.6	10.4	5.7	2.8	1:4.2	4.2	2.6	.18	6.8	13.0	.9	4.6	4.3
28	3.0	10	61.7	14.2	15.1	7.9	7.6	49.8	19.0	10.2	5.3	1:4.3	5.6	3.7	.25	7.1	13.7	1.3	8.2	7.6

TABLE XV.— YOUNG HENS FED VEGETABLE FOOD. LOT XVIII.

A Ration of Vegetable Food Only.

Number of days in period.	Average weight per fowl during period.	Number of hens.	Average per fowl for period. Mixture 2.	Wheat.	Corn.	Barley.	Oats.	Alfalfa hay.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Number of eggs.	Weight of eggs.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound of eggs produced.	Dry matter in food for each pound of eggs produced.
	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.		Ozs.	Ozs.	Cts.	Lbs.
28	3.2	15	41.5	11.7	11.1	5.9	5.9	11.2	13.8	3.3	2.8	1:4.4	3.1	2.7	.15	4.3	7.7	.8	9.0	9.8
28	3.4	15	57.9	10.9	11.1	5.7	5.5	7.5	16.3	3.6	3.3	1:4.3	3.5	3.0	.18	11.0	21.1	.9	3.7	4.0
28	3.3	10	53.2	14.1	8.5	7.0	6.9	10.7	16.3	3.8	3.3	1:4.3	3.6	3.1	.18	17.1	33.4	.9	2.4	2.6
28	3.1	10	59.8	14.7	20.8	7.1	7.3	10.7	18.9	4.3	4.0	1:4.5	4.3	3.7	.21	16.5	32.1	1.2	3.0	3.2
								Green.												
28	3.0	10	48.8	14.5	0	9.4	6.1	42.7	14.8	3.4	3.0	1:4.2	4.3	2.8	.16	13.7	26.3	.9	2.8	2.9
35	2.8	10	79.2	26.7	0	18.0	7.6	53.3	23.7	5.3	4.7	1:4.3	5.3	3.6	.22	12.6	24.5	1.3	5.0	5.1
21	2.4	10	25.6	24.0	0	5.7	3.2	33.6	10.1	2.3	1.9	1:4.7	4.4	2.7	.18	4.0	7.4	1.2	8.3	7.8
28	2.5	9	54.3	20.1	0	11.4	1.3	49.8	16.4	3.8	3.1	1:4.3	4.9	3.1	.19	4.8	9.2	1.2	9.0	9.3

TABLE XVI.— OLD HENS FED ANIMAL FOOD. LOT XIX.

Thirty-six per ct. of the Protein from Animal Food.

Number of days in period.	Average weight per fowl during period.	Number of hens.	Average per fowl for period. Mixture 1.	Corn.	Wheat.	Barley.	Oats.	Alfalfa hay.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Numbe of eggs.	Weight of eggs.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound of eggs produced.	Dry matter in food for each pound of eggs produced.
	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.		Ozs.	Ozs.	Cts.	Lbs.
28	6.4	11	72.0	15.5	14.7	7.7	7.7	9.3	20.6	11.6	5.6	1:4.1	4.5	3.9	.25	7.3	15.9	.6	7.8	6.9
28	6.3	11	55.0	11.5	12.0	6.2	6.2	9.3	16.2	9.0	4.4	1:4.1	3.6	3.1	.20	7.1	15.5	.5	6.3	5.6
28	6.0	11	62.7	14.3	14.5	7.2	7.2	9.3	18.5	10.2	5.0	1:4.2	4.1	3.6	.23	14.6	31.5	.6	3.6	3.2
								Green.												
28	5.8	11	55.8	12.7	12.6	5.6	5.6	37.3	16.4	9.0	4.6	1:4.2	4.6	3.2	.20	12.5	27.3	.5	3.6	3.2
28	5.6	11	52.3	12.9	11.4	5.7	5.7	37.3	15.7	8.5	4.4	1:4.2	4.5	3.0	.19	10.6	22.7	.5	4.1	3.7
28	5.6	11	61.2	13.5	16.8	9.1	9.1	40.7	19.0	10.1	5.2	1:4.3	5.4	3.7	.26	10.0	21.3	.7	5.4	4.9
28	5.9	11	70.3	14.3	12.6	5.8	5.8	40.7	19.7	11.1	5.5	1:4.1	5.3	3.7	.26	10.6	22.6	.6	5.1	4.6

Table XVII.—Old Hens Fed Vegetable Food. Lot XX.

A Ration of Vegetable Food Only.

Number of days in period.	Average weight per fowl during period.	Number of hens.	Average per fowl for period. Mixture 2.	Wheat.	Corn.	Barley.	Oats.	Alfalfa hay.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Number of eggs.	Weight of eggs.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound of eggs produced.	Dry matter in food for each pound of eggs produced.
	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.		Ozs.	Ozs.	Cts.	Lbs.
28	5.7	11	69.3	13.1	13.8	7.3	7.3	9.3	19.7	4.4	4.1	1:4.3	4.3	3.7	.20	12.0	24.7	.6	3.9	4.2
28	5.3	11	51.9	13.6	13.2	5.1	6.4	9.3	15.9	3.6	3.3	1:4.4	3.6	3.1	.16	9.8	20.2	.6	4.0	4.2
28	4.9	11	52.2	14.2	10.3	8.6	6.1	9.3	16.1	3.7	3.3	1:4.4	3.6	3.1	.17	10.9	22.1	.6	3.7	3.9
								Green.												
28	4.7	11	52.3	15.3	....	8.9	5.2	37.3	15.2	3.4	3.0	1:4.2	4.2	2.8	.15	4.6	9.5	.6	8.0	8.3
28	4.6	11	47.8	15.6	....	12.0	5.2	37.3	14.7	3.3	2.9	1:4.3	4.2	2.8	.15	5.4	10.2	.6	7.3	7.6
28	4.4	11	47.4	17.7	....	10.9	6.2	40.7	14.9	3.4	3.0	1:4.4	4.4	2.9	.17	5.9	11.5	.7	6.7	6.9
28	4.1	11	51.6	14.1	....	10.2	6.2	40.7	15.3	3.5	3.1	1:4.2	4.4	2.8	.17	4.7	9.2	.7	8.2	8.7

RELATIVE EFFICIENCY AND ECONOMY OF THE RATIONS FOR HENS.

About 13 per ct. more food was eaten and 31 per ct. more eggs were laid by Lot XVII having the ration containing animal meal than by Lot XVIII. During the thirty-two weeks the average egg production per hen was 110.1 eggs for Lot XVII and 84 eggs for Lot XVIII. Eggs from both lots averaged about the same in weight. The amount of dry matter in the food for each pound of eggs produced was 3.7 pounds for Lot XVII and 4.3 pounds for Lot XVIII. The cost of food for each pound of eggs produced was the same for both lots, 4.1 cents, and the food cost per dozen eggs was 5.9 cents.

Lot XIX ate nearly 15 per ct. more food than Lot XX and laid over 36 per ct. more eggs. During the twenty-eight weeks the average egg production per hen was 72.7 for Lot XIX and 53.3 for Lot XX. The eggs from Lot XIX averaged somewhat larger. The amount of dry matter in the food for each pound of eggs produced was 4.3 pounds for Lot XIX and 5.5 pounds for Lot XX. The cost of food for each pound of eggs produced was 4.8 cents for Lot XIX and 5.2 cents for Lot XX. The food cost per dozen eggs was 7.8 cents for Lot XIX and 7.9 cents for Lot XX. With these two lots of older hens which had not been under the effect of similar rations before the experiment began there was no difference in the laying noticeable during the first twelve weeks, but after the cumulative effect of the rations began to be felt the superiority of the one ration for sustained egg production became more evident. A study of the tabulated data will show this.

With the two lots of younger birds, which had been since hatching under the influence of somewhat similarily contrasted rations, the difference in egg production was apparent from the start. This difference was even more noticeable after several months although the lot having the animal food had been laying longer under the influence of the preliminary rations before this experiment began. For short periods during part of the laying

season the vegetable food ration was used as efficiently as the other, but the subsequent decline in egg production was more rapid than under the other ration. It will be noticed by referring to the tabulated data that the birds in Lot XVII were during every period somewhat heavier than those in Lot XVIII. This was due to the actual difference in size and not to accumulation of fat. This difference between the lots had been much more noticeable before they reached maturity. No particular differences were noticed in regard to broodiness or molting.

OBSERVATIONS RELATIVE TO THE EGGS.

During the first few months a cockerel was kept with each of the two Lots XIX and XX. These birds were alternated between the two lots so that any difference in the general fertility of the eggs might not be attributable to any difference in male birds. The eggs from Lot XIX showed a somewhat greater percentage of fertility than those from Lot XX but there was little difference in the vitality of the germs.

During about four months one cockerel was kept alternately with Lots XVII and XVIII. Eggs were examined several times during the season both when they were probably at their best and later when they were poor. On the average there was a large percentage of fertile eggs, there were fewer of the very weak germs, and the proportion of chicks hatched from the tested eggs was greater for Lot XVII.

Two lots, ten in each, of two year old hens were also fed these contrasted rations for a few months, although full data were not collected. One male bird was kept alternately with the two lots. Eggs from the two lots showed the same percentage of fertility, but there were fewer weak germs in the eggs from the lot having the animal food ration and more chicks were hatched from the tested eggs.

Eggs from all the lots were sometimes kept for a long time before use, but contrasted lots were treated alike. Eggs from

none of these lots were so good for hatching as eggs from some hens having practically free run, nor as eggs from some other matings of birds kept confined. No general differences were apparent in the average weights attained by the chicks hatched from eggs from the several contrasted lots, nor in the vigor of the chicks while growing.

There was some difference generally in the size of the eggs in favor of the lots having the animal food. But little difference in the nutritive value of the eggs was found by chemical analysis. Such differences as were found will be later considered in connection with other work. The shells were generally heavier on eggs from those birds having the animal food ration. Twenty tests of the table qualities of the eggs were made by ten different families. Preferences did not all coincide. Eggs from Lots XVII and XVIII were on the average about equally preferred, while a nearly unanimous opinion favored eggs from Lot XIX over those from Lot XX. Opinion seemed to be influenced favorably by the generally darker colored yolks and firmer consistency of the eggs from hens having the animal food. When a preference in regard to flavor was expressed it was nearly always in favor of the eggs produced under the vegetable food ration.

SECOND SERIES OF EXPERIMENTS.

In another series of experiments two lots of chicks were fed for nine weeks and four lots for eleven weeks. Two lots of ducklings were fed for nine weeks and two lots of laying hens for seven months. The contrasted feeding, as in the former experiments, began with the chicks and ducklings when they were one week old and continued until they were ten or twelve weeks old. The same conditions existed in regard to management and accommodations.

RATIONS IN THE SECOND SERIES.

One ration for chicks and hens consisted of wheat, corn and a mixture, No. 3, composed of 27 parts by weight of corn meal,

25 parts of animal meal, 5 parts each of wheat bran and malt sprouts, 3 parts each of wheat middlings and Buffalo gluten meal, and 2 parts each of buckwheat middlings and pea meal. The contrasted ration consisted of wheat, corn and a mixture, No. 4, composed of 12 parts of wheat bran, 11 parts of King gluten meal, 9 parts each of malt sprouts, buckwheat middlings and bone ash, 6 parts of O. P. linseed meal, 5 parts of pea meal, 4 parts of corn meal, 3 parts each of brewer's grains and ground flaxseed, and 2 parts of wheat middlings. To every 360 pounds of each mixture one pound of salt was added. The ducklings had wheat bran and corn meal with each of the contrasted mixtures. Green alfalfa was fed to every lot. Sand and coarse grit were liberally supplied to the chicks and ducklings and grit and oyster shells to the hens.

The valuations assumed for the foods have been mentioned on page 78. The average composition of each food used in these experiments is shown in the following table. Special analyses of the green alfalfa and alfalfa hay were not made but the average of many analyses showing the composition of numerous samples fed in previous experiments were used in the calculation of rations. See page 79.

TABLE XVIII.— COMPOSITION OF FOODS USED IN THE SECOND SERIES OF POULTRY FEEDING EXPERIMENTS.

Food.	Water.	Ash.	Protein.	Albuminoids.	Fibre.	Nitrogen-free extract.	Fats (ether extract).
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Mixture 3	10.2	12.7	25.1	22.1	3.3	42.8	5.9
Mixture 4	10.4	13.4	22.6	20.7	5.3	41.2	6.6
Wheat...............	13.4	1.9	11.3	11.0	2.0	69.5	1.9
Cracked corn	13.0	1.3	9.3	8.8	1.3	70.9	4.2
Wheat bran	12.8	6.5	14.1	12.5	10.8	50.9	4.9
Corn meal	11.5	1.4	10.3	9.6	1.4	71.0	4.4

EXPERIMENT WITH CHICKS, SECOND SERIES.

The lots of chicks, XI, XIII and XV were fed the ration containing the animal meal and Lots XII, XIV and XVI were fed the contrasted ration of vegetable foods supplemented by bone ash. Two-thirds of the chicks in Lots XI, XII, XIII and XIV were W. Wyandotte-W. Leghorn crosses and the remainder Leghorns and Wyandottes. The other two lots contained about the same proportion of the cross-bred chicks, the remainder being mostly Wyandottes with a few Plymouth Rocks.

After the chicks in Lots XI and XII were ten weeks old the largest cockerels were removed and the remainder fed for two weeks longer on the same rations. The other four lots were fed until the chicks were twelve weeks old without separating the cockerels. The different lots were fed freely — all the food they would readily eat. The nutritive ratios of the rations were nearly alike, the ratio for the vegetable-food ration being however slightly wider as in the preceding experiments. The contrasted rations in this series were more nearly alike in regard to the relations of the protein, ash and fats to the total dry matter. The vegetable-food ration contained a slightly less proportion of protein and a slightly larger proportion of ash and of fats, but these differences were very small.

The data secured in feeding the six lots of chicks are given in the accompanying tables.

RELATIVE EFFICIENCY AND ECONOMY OF THE RATIONS FOR CHICKS.

The ration containing the animal meal was eaten somewhat more freely. The gains made by the contrasted lots were, however, very nearly equal. Lot XI ate nearly 12 per ct. more food calculated on the basis of dry matter than did Lot XII, Lot XIII ate nearly 16 per ct. more than Lot XIV and Lot XV over 9 per ct. more than Lot XVI. The gain in weight made by Lot XII was less than 4 per ct. greater than that made by Lot XI, the gain made by Lot XIII was nearly 10 per ct. greater than

that made by Lot XIV and the gain made by Lot XVI was about 7 per ct. greater than that made by Lot XV. The amount of dry matter in the food consumed for each pound gain in weight was 4.4 pounds for Lot XI and 3.8 pounds for Lot XII; the amount was 4.7 pounds for Lot XIII and 4.5 pounds for Lot XIV. It was 5.8 pounds for Lot XV and 5.0 pounds for Lot XVI. The figures show that while the rapidity of growth was about the same under both rations, the vegetable-food ration was used more efficiently by the growing chicks. A smaller amount of food was required to produce results equal to those produced by a much larger amount under the ration containing animal food.

The difference in the cost of food was due not so much to the somewhat greater consumption under the one ration, but more to the difference in cost of the two mixtures which constituted half the food in the respective rations. The difference in the food cost of the gain made is therefore due not alone to the somewhat greater efficiency of the one ration but more to the valuation of the different foods necessarily used.

The food cost of each pound gain in weight made by Lot XI was 5.3 cents and of that made by Lot XII 4.2 cents. For Lot XIII the cost was 5.6 cents and for Lot XIV 4.9 cents. For Lot XV the cost was 7.0 cents per pound and for Lot XVI 5.4 cents per pound. In rapidity of growth there was little practical difference, equal weights being reached by contrasted lots at the same age. While at ten weeks of age equal weights had been attained by contrasted lots, at twelve weeks the average for Lot XIII was slightly heavier than that of Lot XIV. The weights of other lots at twelve weeks still bore the same relation.

EXPERIMENT WITH DUCKLINGS, SECOND SERIES.

Of the two lots of Pekin ducklings, Lot C was fed the ration containing animal food and Lot D the vegetable food ration with the bone ash. In the accompanying tables the data in regard to the feeding are given up to the age of ten weeks. After ten

TABLE XIX.—CHICKS FED ANIMAL FOOD. LOT XI.

Thirty-eight per ct. of the Protein in the Ration from Animal Food.

Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Average per fowl for period. Mixture 3.	Wheat.	Corn.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
7	1	.1	99	1.9	.5	.5	...	.6	.3	.1	1:3.3	.4	.4	.03	.6	2.8	4.9	4.1
14	2	.	98	7.1	1.8	1.8	.6	2.2	1.0	.5	1:3.3	.8	.7	.05	2.4	3.0	4.8	4.0
14	4	.5	97	11.5	2.5	2.5	1.7	3.5	1.6	.9	1:3.2	1.3	1.1	.08	3.3	2.6	5.5	4.5
14	6	.8	96	15.2	3.7	3.8	3.5	4.7	2.1	1.2	1:3.3	1.9	1.5	.11	4.9	2.3	5.1	4.3
14	8	1.2	93	20.2	5.4	5.3	5.4	6.4	2.8	1.6	1:3.3	2.6	2.0	.15	5.6	2.0	6.1	5.1
*14	10	1.7	75	26.6	6.4	6.4	5.2	8.2	3.7	2.0	1:3.3	3.2	2.6	.19	8.9	1.8	4.8	4.1

* After removal of the largest cockerels.

TABLE XX.— CHICKS FED VEGETABLE FOOD. LOT XII.

All Organic Matter in the Ration from Vegetable Food. Bone Ash Added.

				Average per fowl for period.														
Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Mixture 4.	Wheat.	Corn.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
7	1	.1	97	1.8	.4	.4	...	.5	.3	.2	1:3.5	.4	.3	.02	.5	2.4	4.7	4.2
14	2	.3	97	6.2	1.8	1.8	.6	1.8	.9	.5	1:3.8	.7	.6	.04	2.2	3.0	4.5	4.0
14	4	.5	95	10.4	2.3	2.3	1.8	2.9	1.5	.8	1:3.6	.2	1.0	.07	3.4	2.5	4.5	4.0
14	6	.8	93	13.7	3.3	3.4	3.6	3.9	2.0	1.1	1:3.7	1.7	1.4	.09	5.2	2.1	4.0	3.6
14	8	1.2	93	17.7	4.6	4.4	5.4	5.2	2.6	1.5	1:3.7	2.3	1.8	.12	6.1	1.7	4.4	4.1
*14	10	1.7	75	22.9	5.7	5.7	5.2	6.7	3.4	1.9	1:3.7	2.8	2.3	.15	8.9	1.6	3.9	3.6

* After removal of largest cockerels.

TABLE XXI.— CHICKS FED ANIMAL FOOD. LOT XIII.

Thirty-seven per ct. of the Protein in the Ration from Animal Food.

Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Average per fowl for period. Mixture 3.	Wheat.	Corn.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts	Ozs.	Ozs.	Cts.	Lbs.
7	1	.2	86	2.4	.5	.5	.3	.7	.3	.2	1:3.2	.5	.4	.03	.9	3.2	4.1	3.4
14	2	.3	86	5.1	1.4	1.4	1.3	1.6	.7	.4	1:3.4	.7	.5	.04	1.8	2.4	4.9	4.1
14	4	.5	86	9.9	2.4	2.5	2.3	3.1	1.4	.7	1:3.3	1.2	1.0	.07	3.2	2.5	5.0	4.3
14	6	.7	86	14.4	3.6	1.5	3.3	4.3	2.0	1.0	1:3.0	1.6	1.3	.10	3.7	2.2	6.1	4.9
14	8	1.1	85	16.3	4.1	6.1	4.6	5.3	2.3	1.3	1:3.5	2.2	1.7	.13	6.3	1.9	4.4	3.9
14	10	1.5	85	26.2	6.5	6.6	5.3	8.1	3.6	2.0	1:3.3	3.2	2.6	.19	5.8	2.0	7.3	6.2

TABLE XXII.— CHICKS FED VEGETABLE FOOD. LOT XIV.

All Organic Matter in the Ration from Vegetable Food. Bone Ash Added.

Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Average per fowl for period. Mixture 4.	Wheat.	Corn.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs
7	1	.1	86	1.9	.5	.5	.3	.6	.3	.2	1:3.8	.5	.4	.03	.5	0	5.9	5.4
14	2	.3	86	5.4	1.4	1.4	1.3	1.6	.8	.5	1:3.7	.7	.5	.04	2.2	2.6	3.7	3.4
14	4	.5	86	9.0	2.2	2.1	2.3	2.6	1.3	.7	1:3.6	1.1	.9	.06	3.2	2.3	4.2	3.8
14	6	.8	85	8.9	2.3	2.4	3.3	2.6	1.3	.8	1:3.7	1.2	.9	.06	4.3	1.5	3.2	3.0
14	8	1.1	84	14.0	3.4	3.4	4.7	4.0	2.1	1.2	1:3.7	1.8	1.4	.09	5.9	1.5	3.5	3.3
14	10	1.4	83	24.5	6.2	6.2	5.4	7.1	3.6	2.0	1:3.7	3.0	2.4	.16	3.7	1.9	10.2	9.3

TABLE XXIII.— CHICKS FED ANIMAL FOOD. LOT XV.

Thirty-five per ct. of the Protein in the Ration from Animal Food.

				Average per fowl for period.														
Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Mixture 3.	Wheat.	Corn.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
7	1	.1	61	1.8	.5	.5	.7	.6	.3	.2	1:3.4	.5	.4	.03	.4	3.1	7.2	6.2
14	2	.3	60	6.8	1.6	1.9	1.9	2.1	.9	.5	1:3.4	.9	.7	.05	2.2	3.2	5.2	4.3
14	4	.4	56	9.6	2.5	2.1	3.2	3.0	1.4	.7	1:3.3	1.2	.9	.07	1.3	3.0	12.8	10.1
14	6	.6	54	11.5	2.8	2.9	5.2	3.7	1.7	.9	1:3.3	1.6	1.2	.08	2.8	2.5	7.1	5.9
14	8	.8	53	16.1	4.1	4.1	6.3	5.2	2.3	1.3	1:3.3	2.2	1.6	.12	3.2	2.5	8.5	7.3
14	10	1.1	52	16.6	4.2	4.1	6.5	5.3	2.4	1.3	1:3.3	2.2	1.7	.12	5.2	1.8	5.4	4.5

TABLE XXIV.— CHICKS FED VEGETABLE FOOD. LOT XVI.

All Organic Matter in the Ration from Vegetable Food. Bone Ash Added.

Number of days in period.	Average age of chicks at beginning of period.	Average weight of chicks at end of period.	Number of chicks.	Average per fowl for period.											Average gain in weight per chick during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
				Mixture 4.	Wheat.	Corn.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.				
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
7	1	.1	61	1.8	.4	.4	.7	.5	.3	.2	1:3.7	.5	.4	.03	.5	2.7	5.9	5.6
14	2	.3	60	5.5	1.4	1.3	1.9	1.6	.8	.5	1:3.6	.7	.5	.04	2.1	2.6	4.0	3.6
14	4	.4	57	9.1	2.0	2.8	3.2	2.7	1.4	.8	1:3.8	1.2	.9	.06	1.9	2.7	7.5	6.7
14	6	.6	56	10.0	2.7	2.8	5.0	3.0	1.5	.9	1:3.8	1.5	1.1	.07	3.1	2.1	5.3	4.8
14	8	.8	55	15.0	2.5	2.6	5.9	4.1	2.2	1.2	1:3.4	1.9	1.4	.09	2.5	2.0	8.1	7.6
14	10	1.1	55	15.4	4.9	4.9	6.1	4.8	2.3	1.4	1:3.9	2.2	1.7	.11	6.1	1.8	4.2	3.9

weeks the growth was much slower although made at a profitable rate for a fortnight or more.

RELATIVE EFFICIENCY AND ECONOMY OF THE RATIONS FOR DUCKLINGS.

There seemed to be no difference in the palatability of the rations. The birds appeared in equally good health under both, and there was no loss in either lot. The ducklings in Lot C grew much faster and ate much more food during all periods of the experiment. As much or more food was eaten at all times by the birds in Lot D in proportion to their size. The consumption of food was 26 per ct. greater for Lot C and the gain in weight 65 per ct. greater.

The dry matter in the food for each pound gain in weight was 3.3 pounds for Lot C and 4.3 pounds for Lot D. The cost of food per pound gain in weight up to ten weeks of age was 8.5 cents for Lot C and 4.1 cents for Lot D. At five weeks of age the average weight of the ducklings in Lot C was 2.5 pounds and in Lot D 1.4 pounds. At eight weeks of age the average weights were 4.5 pounds for Lot C and 2.9 pounds for Lot D. At ten weeks of age the weights were 5.75 pounds for Lot C and 3.7 pounds for Lot D, and at twelve weeks the average weights were 6.4 pounds and 4.7 pounds respectively. The average weight of two pounds was attained by Lot C 1.8 weeks sooner than by Lot D, the average weight of three pounds 2.3 weeks sooner, the average weight of four pounds 3.3 weeks sooner and the average weight of five pounds about a month sooner. The birds in Lot C reached the average weight of six pounds at 10.4 weeks of age. Those in Lot D did not reach this weight while feeding records were kept, but birds from this lot attained later in the season practically the same size as those more quickly grown. Under the vegetable food ration with bone ash the ducklings were able to make a moderate and regular growth and remain in continual good health. This, other lots of ducklings had be-

TABLE XXV.—DUCKLINGS FED ANIMAL FOOD. LOT "C."

Thirty-six per ct. of the Protein in the Ration from Animal Food.

Number of days in period.	Average age of ducklings at beginning of period.	Average weight of ducklings at end of period.	Number of ducklings.	Average per fowl for period. Mixture 3.	Wheat bran.	Corn meal.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per fowl during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
7	1.2	.6	30	7.9	1.5	3.1	.9	2.5	1.2	.7	1:3.3	1.9	1.6	.11	4.4	3.5	2.7	2.6
7	2.2	1.0	30	12.1	2.4	5.0	.9	3.9	1.8	1.1	1:3.4	2.9	2.5	.17	6.8	3.1	2.7	2.6
7	3.2	1.8	30	18.7	4.0	7.4	2.8	6.1	2.8	1.6	1:3.4	4.7	3.9	.26	12.0	2.8	2.4	2.3
7	4.2	2.6	30	22.6	4.9	9.1	2.8	7.4	3.4	2.0	1:3.4	5.6	4.8	.31	13.5	2.2	2.6	2.5
7	5.2	3.3	30	28.3	5.3	10.7	4.7	9.1	4.2	2.4	1:3.3	7.0	5.8	.38	10.2	2.0	4.2	4.0
7	6.2	3.9	30	26.1	5.3	12.0	4.7	8.7	3.9	2.4	1:3.5	6.9	5.7	.37	9.7	1.6	4.3	4.1
7	7.2	4.7	30	28.9	4.5	10.5	7.5	9.3	4.3	2.5	1:3.3	7.3	5.8	.39	14.0	1.4	3.1	2.9
7	8.2	5.2	30	31.5	7.1	11.7	7.5	10.4	4.8	2.8	1:3.4	8.3	6.7	.43	7.0	1.3	7.0	6.7
7	9.2	5.9	30	23.5	5.6	10.1	7.5	8.0	3.6	2.2	1:3.5	6.7	5.2	.33	11.7	.9	3.2	3.1

TABLE XXVI.— DUCKLINGS FED VEGETABLE FOOD. LOT "D."

All Organic Matter in the Ration from Vegetable Food. Bone Ash Added.

Number of days in period.	Average age of ducklings at beginning of period.	Average weight of ducklings at end of period.	Number of ducklings.	Average per fowl for period. Mixture.	Wheat bran.	Corn meal.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Average gain in weight per fowl during period.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound net gain in weight.	Dry matter in food for each pound gain in weight.
	Weeks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
7	1.2	.5	29	8.1	1.5	3.2	1.0	2.4	1.2	.7	1:3.7	2.0	1.6	.10	2.7	3.9	4.1	4.3
7	2.2	.7	29	7.2	1.9	3.5	1.0	2.3	1.2	.7	1:3.9	1.9	1.6	.10	3.2	2.7	3.4	3.6
7	3.2	1.1	29	12.3	2.2	4.5	2.9	3.7	1.9	1.2	1:3.7	3.1	2.5	.15	6.4	2.7	2.6	2.7
7	4.2	1.5	29	13.8	2.7	5.4	2.9	4.2	2.2	1.3	1:3.7	3.5	2.9	.17	6.5	2.2	2.9	3.1
7	5.2	2.0	29	16.4	3.1	6.4	4.8	5.0	2.6	1.5	1:3.7	4.4	3.4	.20	6.8	2.0	3.3	3.5
7	6.2	2.2	29	15.9	3.2	6.8	4.8	5.0	2.5	1.6	1:3.8	4.4	3.5	.20	4.6	1.7	4.9	5.2
7	7.2	3.1	29	31.5	5.2	11.7	7.7	9.4	4.9	2.9	1:3.7	8.0	6.4	.38	13.4	2.4	3.2	3.4
7	8.2	3.4	29	26.3	4.6	12.0	7.7	8.1	4.1	2.6	1:3.8	7.2	5.7	.33	5.1	1.8	7.3	7.8
7	9.2	3.8	29	25.7	6.1	8.9	7.7	8.0	4.1	2.5	1:3.7	6.9	5.4	.32	5.3	1.5	8.1	7.2

fore been unable to do on rations wholly of vegetable food or on such rations supplemented by a liberal amount of skimmilk curd. The bone ash appeared therefore to partly supply a deficiency which had existed in some other rations, but it did not bring the ration anywhere near to the efficiency of the ration containing animal meal. The contrasted rations were nearly alike in chemical composition so far as the groups of constituents are *ordinarily* considered in feeding.

EXPERIMENT WITH LAYING HENS, SECOND SERIES.

The two lots of laying hens which were fed the contrasted rations were Leghorns and had been laying well for two or three months before the experiment began. The two lots were alike at the start. The ration containing animal food was fed to Lot XXI and the vegetable food ration to Lot XXII. The hens were liberally fed but not more than was promptly and readily eaten. Chopped alfalfa hay was fed during the first period and green alfalfa during two others. For about three months the hens were allowed to get their green food from grass runs and the amount eaten was estimated from the amount of green forage eaten at other times when it was freely fed. An interrogation point accompanies the statement of amount of green fodder for the periods when it was estimated. The records of feeding and the results obtained are stated in condensed form in the accompanying tables.

RELATIVE EFFICIENCY AND ECONOMY OF THE RATIONS FOR HENS.

The difference in food consumption under the two rations was practically nothing. For the thirty weeks there was only about one-half per ct. difference in the total dry matter of the food. Up to the beginning of the last period the total consumption was exactly the same. The rations were intended to correspond very closely in regard to the proportions of constituents, and this they proved to do, although there were slight differences. The animal

TABLE XXVII.—HENS FED ANIMAL FOOD. LOT XXI.

Thirty-four per ct. of the Protein in the Ration from Animal Food.

Number of days in period.	Average weight per fowl during period.	Number of hens.	Average per fowl for period. Mixture 3.	Wheat.	Corn.	Alfalfa hay.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day	Number of eggs.	Weight of eggs.	Dry matter in food per day for each pound live weight fed.	Cost of food for each pound of eggs produced	Dry matter in food for each pound of eggs produced.
	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.		Ozs.	Ozs.	Cts.	Lbs.
35	3.4	14	79.5	20.9	20.0	23.8	26.5	12.0	6.3	1:3.3	3.8	3.4	.23	24.9	48.0	1.0	2.8	2.5
						Green.												
35	3.3	14	73.0	18.5	18.0	76.2(?)	25.3	11.3	6.1	1:3.4	5.3	3.3	.21	25.0	48.3	1.0	2.6	2.4
35	3.3	13	80.0	19.5	20.1	80.0(?)	27.5	12.3	6.6	1:3.4	5.7	3.5	.23	21.8	46.8	1.1	2.9	2.7
35	3.1	13	71.7	18.2	18.0	86.8(?)	25.4	11.3	6.1	1:3.4	5.6	3.3	.22	17.6	32.8	1.1	3.8	3.5
35	3.1	13	67.2	17.2	17.0	86.8	24.0	10.7	5.8	1:3.4	5.4	3.1	.21	15.9	30.6	1.0	3.9	3.6
35	3.1	13	62.2	15.1	15.3	86.8	22.4	10.0	5.4	1:3.4	5.1	2.9	.19	11.2	22.8	.9	4.7	4.5

TABLE XXVIII.—HENS FED VEGETABLE FOOD. LOT XXII.

All Organic Matter in the Ration from Vegetable Food. Bone Ash Added.

Number of days in period.	Average weight per fowl during period.	Number of hens.	Average per fowl for period.													Dry matter in good per day for each pound live weight fed.	Cost of food for each pound of eggs produced.	Dry matter in food for each pound of eggs produced.
			Mixture 2.	Wheat.	Corn.	Alfalfa hay.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Number of eggs.	Weight of eggs.			
	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs	Ozs.	Cts.		Ozs.	Ozs.	Cts.	Lbs.
35	3.3	15	74.0	18.8	19.1	13.1	22.8	11.7	6.3	1:3.7	3.6	3.1	.19	23.9	42.2	1.0	2.6	2.4
						Green.												
35	3.2	15	68.3	18.3	17.7	70.0(?)	22.1	11.1	6.2	1:3.7	5.0	3.1	.18	23.1	43.5	1.0	2.5	2.5
35	3.2	13	81.6	19.6	19.2	80.0(?)	25.8	13.1	7.3	1:3.7	5.7	3.6	.21	22.9	42.7	1.1	2.9	2.9
35	3.3	13	75.9	18.5	18.9	86.2(?)	24.6	12.4	6.9	1:3.7	5.7	3.4	.21	18.1	33.7	1.0	3.5	3.5
35	3.2	13	76.4	18.2	18.2	86.2	24.6	12.5	6.9	1:3.7	5.7	3.4	.21	17.2	32.3	1.1	3.7	3.7
35	3.2	13	64.6	16.1	16.1	86.2	21.5	10.8	6.0	1:3.7	5.2	3.0	.18	....	14.7	1.0	7.0	7.1

food ration supplied on the average a little more protein and a little less of ash and fats than the contrasted ration.

During nearly six months there was very little difference in egg production, the difference being less than three per ct. in favor of Lot XXI. After this the falling off was more rapid for Lot XXII so that the egg yield for the whole time was about six per ct. greater for Lot XXI. The average number of eggs laid per hen during the thirty weeks was 119.4 for Lot XXI and 112.7 for Lot XXII. For every pound of eggs produced there were 3 pounds of dry matter in the food for Lot XXI and 3.2 pounds for Lot XXII. For nearly six months the proportion of dry matter in the food for each pound of eggs produced was 2.8 pounds for Lot XXI and 2.9 pounds for Lot XXII. Although the cost of food was somewhat more under the animal food ration, the egg yield was enough larger to make the food cost of eggs about alike for both lots. For the whole time the average cost for each pound of eggs was 3.2 cents for each lot. For all but the last period the average was 3.1 cents for Lot XXI and 3.0 cents for Lot XXII. The average food cost per dozen eggs was, for the thirty weeks, 4.7 cents for Lot XXI and 4.6 cents for Lot XXII.

No general difference was noticed in regard to molting.

OBSERVATIONS ON THE EGGS.

Two cockerels were kept, one with each lot, during the first three and one-half months. The birds were alternated between the two lots so that average and general differences in the eggs would appear justly credited to the hens. The eggs from Lot XXI proved better from the breeders' standpoint than those from Lot XXII. Eggs from both lots were sometimes kept several weeks. Five hundred eggs from each lot were examined and incubated. Eighty-six per ct. of those from Lot XXI were fertile, 19 per ct. of the fertile eggs had very weak germs and 77 per ct. of the tested eggs hatched strong chicks. Of those from Lot XXII, 78 per ct. were fertile, 34 per ct. of the fertile eggs had

very weak germs and 64 per ct. of the tested eggs hatched strong chicks. Early in the season some of the eggs from both lots were much better than these average results show and later some were much inferior. The cockerels used were undoubtedly responsible for many fluctuations in fertility of the eggs, for there were pronounced differences consistently following changes of the male birds.

A circumstance was noticed in the later hatches which seems worthy of record for it suggests a difference in the prepotency of the hens in the two lots. The hens used were thoroughbred S. Combed W. Leghorns and the cockerels were pure W. Wyandottes. From Lot XXI almost exactly one-half of the number of chicks hatched (52 per ct.) had the single comb characteristic of the female parent, while all the chicks from Lot XXII had the rose comb characteristic of the male parent. Unfortunately these observations were limited and apply only to about eighty chicks of the later hatches as the opportunity was lost for observing the chicks of the earlier hatches.

No difference in the vigor of the chicks from the two lots while growing was observed.

SUMMARIZED DATA.

With every lot of chicks in the first series (Lots II, IV, VI, VIII and X) having a ration wholly of vegetable origin more food was required to produce a pound gain than by the contrasted lot (Lots I, III, V, VII, IX). On the average for the ten lots about 23 per ct. more food was required.

The two lots of laying hens, XVIII and XX, required on the average about 23 per ct. more food for each pound of eggs produced than did Lots XVII and XIX having animal food.

Lot B of ducklings required about 2.3 times as much food for each pound gain in weight as did Lot A having the unchanged ration containing animal food.

Every lot of chicks in the second series (Lots XI, XIII and XV) having a ration containing animal food required more food

for each pound gain than did the contrasted lot (Lots XII, XIV and XVI) having vegetable food supplemented by bone ash. On the average about 13 per ct. more food was required.

Less than 7 per ct. more food was required by Lot XXII of laying hens for each pound of eggs produced than was required by Lot XXI.

Lot D of ducklings required over 30 per ct. more food for each pound of gain in weight than did Lot C having animal food.

GENERAL CONCLUSIONS.

In some feeding experiments conclusive results can be obtained in a direct manner from a few animals. In other feeding experifents, however, where mixed foods must necessarily be used longer than for a short time, many conditions exist which cannot be subjected to particular control, and the nature of the evidence is so largely circumstantial that conclusions can only be satisfactory when they are based upon data from several feeding trials and a larger number of animals. In these experiments relating to the use of animal food, including the preliminary trials reported in Bulletin 149, 1,000 chicks and 170 ducklings were grown to marketable size; 90 hens and 40 cockerels were used. The results, therefore, not any of which are of conflicting nature, seem to justify certain conclusions.

In general, rations containing animal food appear more palatable than rations of somewhat similar chemical composition consisting wholly of vegetable food. Rations in which the lack of palatability was overcome by using an unusual variety of grain foods were inferior for growing chicks and laying hens and decidedly inferior for ducklings to rations in which nearly one-fifth of the dry matter was supplied by animal food. After the period of most rapid growth had passed and the young birds approached maturity the difference in the efficiency between such rations rapidly disappeared.

Although it was found possible, when using a large number of foods in contrasted rations of these kinds, to have the ordinary groups of organic compounds in approximately equal proportions there was always a much larger amount of mineral matter in the one ration owing to the bone of the animal meal. So there was sometimes nearly three times as much phosphorous in the one ration as in the other. Calculating all the phosphorous as phosphoric acid, there was in the animal meal ration fed to chicks and hens generally about 3.9 per ct. of phosphoric acid, while in the ration of vegetable origin there was about 1.4 per ct. In the contrasted rations for ducklings there were 4.0 per ct. and 1.9 per ct. of phosphoric acid, respectively.

By using bone ash in another series of experiments, the amount of phosphorus was made to equal and sometimes slightly exceed that in the animal food ration, although all the organic matter was still derived from vegetable food. There was in the animal food ration fed to chicks, phosphorus equivalent to about 3.9 per ct. of phosphoric acid and in the contrasted ration to about 4.0 per ct. The animal food ration for ducklings contained about 3.6 of phosphoric acid and the vegetable food ration about 4.0 per ct. Both rations for laying hens contained about 3.6 per ct. of phosphoric acid. Practically the same relative amounts of protein, fats and carbohydrates existed in the contrasted rations. The vegetable food ration, thus supplemented by the mineral matter of bone ash, when fed to chicks, proved fully equal to the ration containing animal meal, so far as rapidity of growth was concerned. In economy it was even somewhat superior, for considerable less food was required for equal results. For laying hens the rations were equal in efficiency for some months, but the ration containing animal food proved somewhat more enduring in its effects. With ducklings the ash-supplemented ration of vegetable food proved decidedly inferior to the corresponding ration containing animal food.

From these results it appears that rations containing a necessary amount of protein and having the relation of the ordinarily

considered constituents satisfactory may be inferior because of a lack of mineral matter, probably phosphates.

Not enough data are now available to show to just what extent the deficiency of lime in the food for the younger chicks may have been responsible for inferior results. With laying hens, lack of lime could not have affected the results considered; for oyster shells were freely supplied, and it has been shown (see Bulletin No. 38) that such material can make good the frequent deficiency of lime.

It appears also that, while a cheaper vegetable food ration can sometimes be made to equal or surpass in efficiency a ration containing animal food by supplementing it with suitable mineral matter, there are plain limitations to its economical use. For laying hens some animal food appears necessary for continued good results. Ducklings without an abundant supply of animal protein in the ration, together with a liberal proportion of mineral matter, seem unable to make any approximation to their normally rapid and most profitable growth.

Although bone ash was used to make good an assumed deficiency in one ration and proved an efficient addition for the purpose, it should not be inferred that its purchase for feeding is to be generally recommended. It was necessarily used to obtain information. Bone ash in the market is expensive. The same amount of mineral matter can be obtained much cheaper in fresh bone or animal meal, of which foods it constitutes an important part. In some instances, of course, dry bones, where no facilities exist for grinding, or green bones in questionable condition, can be safely and economically used when charred or reduced to ash. The very desirable organic matter associated with fresh or cooked bones should not be wasted.

REPORT

OF THE

Department of Bacteriology

H. A. Harding, *Bacteriologist.*
L. A. Rogers, *Student Assistant.*

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I. The efficiency of a continuous pasteurizer at different temperatures.

REPORT OF THE BACTERIOLOGIST.

THE EFFICIENCY OF A CONTINUOUS PASTEURIZER AT DIFFERENT TEMPERATURES.*

H. A. Harding and L. A. Rogers.

SUMMARY.

These tests were made by passing mixed whole milk through a Danish continuous pasteurizer. At 70°C. (158°F.) the efficiency of the continuous pasteurizer varies greatly from day to day. Tests upon 14 different days gave an average of 15,288 living germs per cubic centimeter left in the pasteurized milk, with a maximum of 62,790 and a minimum of 120 germs.

At 80° C. (176° F.) the reduction in germ content is both very uniform and very great. Tests upon 25 different days gave an average of only 117 living germs per cubic centimeter in the pasteurized milk, with a maximum of 297 and a minimum of 20 germs.

At 85° C. (185° F.) the average reduction is not more marked than at 80° C. but the range of variation is less. This temperature has the added advantage, according to Dr. Bang, of removing the danger from germs of tuberculosis in the milk.

Even when the whole milk was heated to 85°C. the butter did not have a permanent cooked flavor.

INTRODUCTION.

An inquiry into the laws which underlie any of the complex commercial processes will progress slowly if each step is deter-

* Reprint of Bulletin No. 172.

mined with a thoroughness that allows of safe generalization from the data obtained.

In order that the reader may see the relation of this piece of work to the problem that is being studied, let the following facts be borne in mind.

THE DANISH SITUATION.

Dairying is one of the principal industries of Denmark and during the past two decades the government has fostered it both by the equipment of experts to study its problems and by protective legislation.

In 1890 Dr. Storch announced that, by changing the kind of bacteria that grow in ripening cream, he was able to change the flavor of the butter.

Dr. Bang, after studying the conditions under which tuberculosis was distributed among cattle, perfected a system of separating the diseased animals from the healthy ones and gradually replacing the former. In carrying out his plan, the feeding of calves upon the skim milk brought from the creamery was found to be a source of danger, but this could be removed by heating the milk momentarily to 85°C. (185°F.).

As the result of these and other investigations, there has spread over Denmark a peculiar method of making butter — a method so successful that, to-day, Danish butter is a standard of excellence wherever it is known.

Cleanliness in all details and an intelligent appreciation of the relation of bacteria to butter-making are widespread, but the key-note of their system is preparation of the starter itself and the cream to receive the starter.

By a starter they rarely mean the mixture of bacteria, desirable and undesirable, which commonly receives that title in New York. They mean a mixture of known kinds, each of which has been found desirable in itself. This united action of several species gives a better flavor to the butter than could be obtained from any single species.

This mixture of germs, when received from a laboratory, is introduced into milk that has been first heated to near the boiling point for 2 hours to kill other bacteria and then cooled below blood heat. This starter is propagated from day to day with so much care that at the end of four to six weeks, when it is finally rejected for a new one, the usual fault with it is merely a too sharp flavor of acid.

The preparation of the cream begins with cleanliness in the barn. Either the whole milk or the cream after separation is heated to free it of objectionable forms before receiving the starter. This heating is only momentary and various temperatures are advocated — those from 70° C. (158° F.) to 95° C. (203° F.) having been used. After heating, the cream is quickly and thoroughly cooled. Formerly cream was heated after separation, both for economy and because of less opportunity for after-contamination.

A knowledge of the increase in feeding value produced by prolonging the period of sweetness, and, later, a desire to prevent the spread of tuberculosis among their calves, caused the skim milk to be heated above 85° C. (185° F.). Since it has been found that the capacity of the separator is increased by skimming at high temperatures and that whole milk can be heated to 90° C. (194° F.) without injury to the flavor of the butter, there is a tendency toward a single heating of the whole milk.

The points of excellence claimed for the Danish product are uniformly good quality and the property of holding its flavor for long periods.

THE AMERICAN SITUATION.

Butter is now selling at from 14 to 28 cents per pound, with less than 15 per ct. of the product bringing the latter price. The quality of the best butter is above reproach, but the lamentable thing is the lack of quantity of such butter. So great is this lack

that during at least a portion of the year it is impossible to buy first-class butter in many of the moderate-sized cities in this, the greatest dairy State in the Union.

These facts show that there is abundant room for improvement, and anything that will raise the average quality of the product will be gladly welcomed, both by the dairyman and the consumer.

After the Danish success became an established fact, Americans attempted to copy their methods, but thus far the results have not been up to their expectations. Tests carried on by the Agricultural Experiment Stations of Wisconsin and Pennsylvania, as well as by the Department of Agriculture at Washington, failed to show that there is any financial gain to be derived from the process when practiced as usually recommended.

Believing that the above failures are due to some of the modifications that the system has undergone in being brought from Denmark to America, this Station has undertaken to follow the process step by step, hoping to find the proper American conditions under which we can not only make a more uniform product, but one that will be sufficiently improved to justify the additional expense in preparation.

The solution of this problem calls for the co-operation of a number of the departments of the Station and will require considerable time; hence, it is proposed to issue the results in a series of bulletins, of which this is the first. While the Bacteriological Department assumes the responsibility for the statements contained in this bulletin, much credit is due our Dairy Expert, Mr. Geo. A. Smith, whose wide experience in dairy matters has materially contributed to the success of the practical side of the work.

WHAT IS MEANT BY PASTEURIZATION.

As long ago as 1782, a Swedish chemist, Scheele,[1] found that after immersing bottles of vinegar in boiling water for a time, the

[1] Hansen, Emil. Chr. Practical Studies in Fermentation, p. 158.

vinegar would not become turbid or spoiled as long as it was kept carefully closed.

Early in the nineteenth century Appert[2] applied this idea of heating inclosed fluids to prevent fermentative changes to the preservation of fruits, vegetables, soups, milk, fruit juices, wine and beer.

A half century later Pasteur turned this knowledge of the effect of heat in delaying fermentation to practical account in combating some of the undesirable fermentations of wine and beer, with such success that the process has been called pasteurization in his honor. Our present methods of canning fruit and vegetables are probably the result of the early discoveries. The application of heat in this way had become such a household matter by the time the process received this special title that the name was not carried over to the ordinary househould heating and a can labeled "Pasteurized Peaches" would to-day be quite a puzzle, although from its manner of preparation it can justly claim that title.

Pasteurization, then, is simply the application of heat to check the activity of fermentation. The temperature used depends upon the substance treated and the end to be attained. The effect upon germ life will vary both with the degree of heat and the length of exposure. The same results can be secured in the killing of *Bacillus tuberculosis* when the milk is heated at 60° C. (140° F.) for 30 minutes or at 85° C. (185° F.) for a very short time.

PASTEURIZATION CONFUSED WITH STERILIZATION.

Sterilization is a good word that has been debased by popular usage. In its true sense it means the total destruction of life. It is often used to mean anything from a simple warming to a thorough boiling. Such words are best used in their true sense

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[2] Loc. cit., p. 159.

or not used at all. It should be remembered that some of the organisms which are often found in milk will successfully withstand boiling for some hours and the sterilization, in the true sense, of any commercial quantity of milk at a single heating is a practical impossibility unless temperatures above that of boiling water are used.

THE TWOFOLD APPLICATION OF PASTEURIZATION TO MILK.

The subject of the pasteurization of milk has been presented to the American public with reference to two distinct problems — the sanitary milk supply of cities and the production of uniformly good butter.

While heat is applied in both cases the methods of application which have been found most successful in each are radically different and an attempt to accomplish either object by the other process has not yet been shown to be practical. The first method is too slow and expensive to be adapted to butter making and the second plan when carried on at a temperature sufficiently high to kill the tubercle bacillus gives an objectionable flavor to the milk. Fortunately this flavor does not remain in the butter.

THE DISCONTINUOUS OR HOUSEHOLD SYSTEM.

About ten years ago when the use of tuberculin was bringing home the alarming prevalence of tuberculosis among our dairy cows and the danger of transmission of the disease to invalids and children through milk seemed self-evident, pasteurization was brought forward as a safeguard from this danger. In this method the milk was heated at a definite temperature for a definite length of time.

At first 67.3°C. (155°F.) for 20 minutes was advocated, but owing to the change brought about in the viscosity of the milk and

cream by exposure to this temperature, heating to 60°C. (140°F.) for 30 minutes is now coming more into favor. According to the researches of Dr. Theobald Smith,[3] 15-20 minutes at 60°C. (140°F.) is sufficient to kill the tubercle bacillus provided the milk is kept stirred so as to prevent the formation of a pellicle at the surface. Higher temperatures and a shorter time would give the same result, but when the temperature of 70°C. (158°F.) is passed the milk takes on a disagreeable, cooked taste. This is largely due to an oxidation of some of the components of the hot milk and it is possible that in the future a way may be found of avoiding this flavor.

The main feature in the discontinuous process is the removal of the danger from disease and this applies not only to tuberculosis but to all other germ troubles which are liable to gain access to the milk before it is heated. The keeping quality of the milk is much improved, especially if proper attention is given to keeping it cool after treatment and the effect of the carelessness and lack of cleanliness which are often prevalent at the barn is in a measure removed. A very commendable practice exists of passing the milk through a separator and remixing the milk and cream before pasteurization. This removes a large part of the hair, excrement, etc., which is so common in the ordinary milk supply of cities.

This method of handling milk for immediate consumption is in successful operation in a number of cities on a large scale. It has much to commend it and when done in a large way it does not increase the cost of production more than a small fraction of a cent a quart.

THE CONTINUOUS OR DANISH SYSTEM.

When the Danish system of butter making was introduced into America pasteurization came as a necessary part of it, but in this case the principal object was the fitting of the cream to receive

[3] Journal of Experimental Medicine, 4: 217–233 (1899).

the starter of selected bacteria so that the desired flavor might be always obtained.

The problem that presents itself is not different from that which confronts every farmer who attempts to grow a field of oats. If he sows his seed upon land already filled with rapidly growing clover, Canada thistles and ragweed his chances of a good oat crop are poor. If he first fits his land and kills off the other plants the oats will have a better chance. To make a success of this it is not necessary to kill off every weed in the field for if the oats are much in the majority and get the start of the others they will control the situation and suppress the weeds.

The bacteria are plants of more simple form than those in the above illustration, but they obey the same laws of competition in growth. If conditions are so arranged that the starter when added to the cream finds the same filled with rapidly growing enemies, the effect of the starter will be largely or wholly lost; while if it is added to cream from which all or nearly all of its competitors have been removed, the starter will assume control of the situation and suppress its enemies.

In the Danish machine the milk is introduced at one end of a cylinder surrounded by steam and flows continuously from the other end having been momentarily heated to the temperature desired.

The temperatures used have had an upward tendency and since Dr. Bang announced that when working with tuberculous cows furnishing the diseased germs in their milk the milk was rendered harmless when passed through one of these machines at 85° C. (185° F.), this has been taken as the Danish minimum legal temperature for heating all the by-products that are to be returned to the farm for feeding purposes.

In a country where the most determined effort is being made to stop the spread of tuberculosis among cattle the value of this protection to a dairyman who has succeeded in freeing his own herd from the contagion, but yet is compelled to raise his calves

upon mixed milk brought from the creamery, should not be overlooked.

In this as in their other acts regarding the suppression of tuberculosis the Danes have shown a laudable moderation and consideration of the rights of all concerned. The legal enactment as to the temperature to be used was not made until the pasteurizing process had been voluntarily adopted and the necessary machinery installed in practically every creamery in the country.

The American promoters of the Danish method, knowing from their previous experiences with the other form of pasteurization that a heating above 70° C. (158° F.) produces a disagreeable flavor in the milk, were either not willing to trust the practical experience of the Danes or hopelessly confused the two problems and recommended 67.3° C. (155° F.) to the American experimenters when the Danish practice is to employ a temperature at least 12.7° C. (25° F.) higher.

The points in which their reasoning went astray were two: First, the cooked taste in milk, at least for the most part, is not a matter of absolute temperature at which the milk is heated, but rather the result of an exposure of hot milk to oxygen. Milk that has been highly heated in a Danish pasteurizer and immediately and thoroughly cooled as is their practice has surprisingly little of the cooked taste. Second, the cooked flavor does not attach itself tenaciously to the fat of which the butter is almost exclusively prepared and butter made from highly heated milk that may have a slightly cooked taste immeditely after churning losses this objectionable flavor in a very short time.

Believing that a failure to properly heat the milk might be a factor in the lack of success of past American experiments our investigations began with this point.

THE PROBLEM STUDIED.

The objective point was to determine the effect upon the germ-life when milk was passed through a continuous pasteurizer at

different temperatures. So far as data were at hand this had been done but twice in America. Both of these tests had been carried out at about 70° C. (158° F.) and the trials were too few in number and the results too contradictory to form a safe basis for generalization.

At the Wisconsin Station[4] it was found that, while there was considerable variation in the effect of a heating of 67.3°–74° C. (155°–165° F.), in some cases as many as 40 per ct. of the bacteria survived and in the tests published this number remaining amounted to over 2,000,000 germs per cubic centimeter.

A different kind of continuous machine was used at the Pennsylvania Station[5] and no numerical results were given, but it was stated that "Heating to this temperature 67.3°–70° C. (155°–158° F.), for this length of time, as was found by culture plates, destroyed few, if any, of the bacteria present in the milk."

Since 70° C. (158° F.) is the lowest temperature which is generally recommended for continuous pasteurizing this was taken as a starting point in our work and when the effect of this temperature had been observed higher degrees were used.

MACHINE USED.

We are indebted to D. H. Burrell & Co., Little Falls, N. Y., for the loan of a continuous pasteurizer made by Konstantin Hansen & Schröder, Kolding, Denmark. This has a rated capacity of 2,500 pounds of milk per hour heated to 70° C. (158° F.)

The accompanying drawing of a cross section (Plate II) explains the essential parts of the machine. The milk enters at the bottom into a central milk chamber. Here it is set in motion by the stirrer revolving 300 times per minute, which spreads the milk out in a thin layer against the wall and finally expels it at the tangential milk outlet above. This outlet has a lateral open-

[4] Pasteurization as Applied to Butter Making, Wis. Agr. Exp. Sta. Bul. 69.
[5] Heated Milk for Butter Making, Penn. Agr. Exp. Sta. Bul. 45.

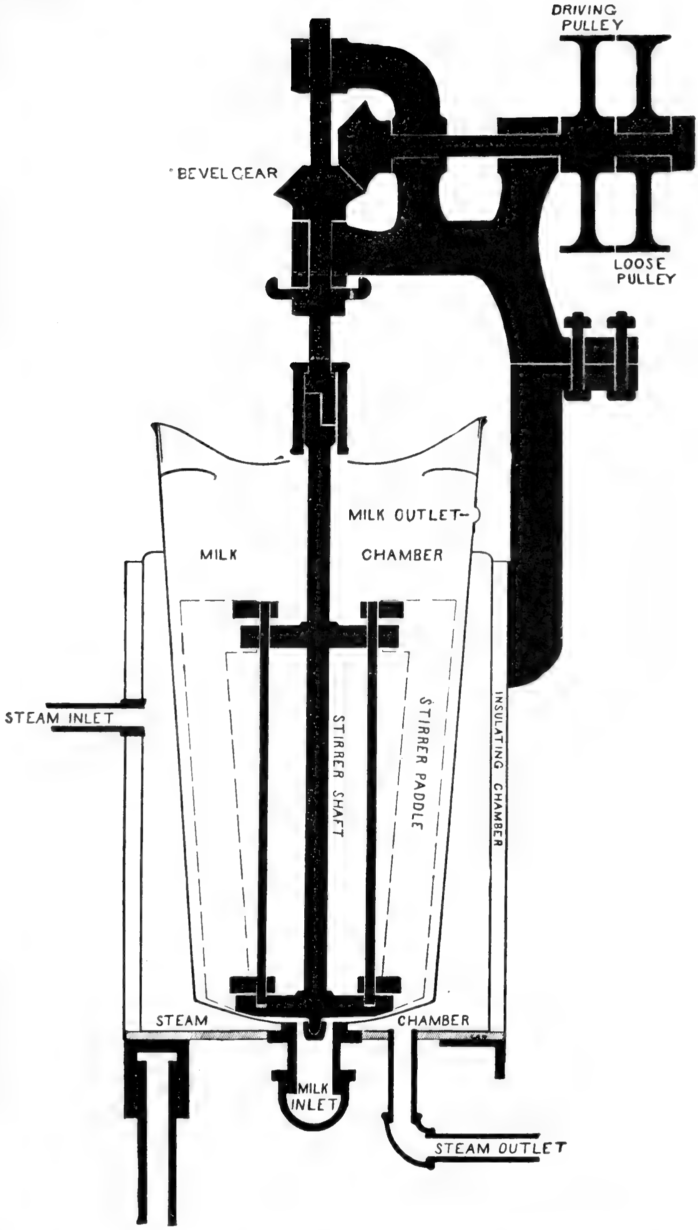

PLATE II.—VERTICAL SECTION OF CONTINUOUS PASTEURIZER.

ing for receiving the thermometer. As the milk is spread out in this thin layer it quickly takes up the heat from the steam chamber surrounding it.

The temperature of the milk is controlled by changing either the valve admitting the steam or the valve regulating the milk flow. A slight change in either of these valves produces a quick response in the mercury column of the thermometer. Usually the milk valve was set to admit about all the milk that could be heated to the desired degree and the slight variations in temperature were controlled by changing the steam valve.

METHOD OF WORK.

In the manipulation of the machine at the different temperatures the effort was always made to give it a fair chance to show what could be expected of it when handled in the average creamery at that temperature. Our ability to give it a fair trial increased as we became familiar with the machine and its manipulation.

The first requisite was a method of regulating the flow of milk and steam so that the temperature might be held constant. When received, the machine was provided with a float intended to control the flow of milk automatically. After testing it in a variety of ways for some weeks it was condemned as too clumsy for our purpose and was removed.

As finally arranged a supply tank placed sufficiently high to give a good fall was connected directly with the base of the pasteurizer and the flow regulated by a hand valve. This brought the milk and the steam valves near together where one man could reach both and still watch the thermometer. The maximum variation, which rarely exceeded 10° C., usually occurred at the beginning of the process before the valves were properly adjusted. This having been accomplished the desired temperature could be maintained with very little variation.

In order to make the control of the temperature as well as the collection of the desired data more accurate the milk was thoroughly mixed in a tempering vat before starting the machine. The arrangement of the apparatus will be better understood by referring to Plate III.

DATA COLLECTED.

In the Dairy the interest centered upon the temperature used and in the Laboratory upon the numerical content of germs in the milk before and after heating. A large amount of data was collected in both places bearing upon a number of points. Notes were taken upon the age, weight, initial temperature and acidity of the milk, the steam pressure in the boiler, the rate of the pasteurization and the maximum, minimum and pasteurizing temperature employed.

Age.— With age there is an increased growth of bacteria and a larger number of spores present. This is what makes the successful pasteurization of milk over 24 hours old so difficult. During a large part of the time the mixted milk was made up of portions 4, 12, 24 and 36 hours old.

Weight.— This varied considerably but averaged 350 lbs. As the machine while in operation contained only about five pounds of milk and all that was really necessary was to hold the temperature at the desired point at the time of taking the sample this was quite enough for our purpose.

Initial temperature.— The termperature of the mixed milk was noted in the tempering vat. For the most part our milk was brought to about 26° C. (78.8° F.) as being a high average temperature for summer conditions. As received ordinarily in creameries in this State milk varies from near the freezing point in winter to 35° C. (95° F.) in rare cases in summer.

The temperature of the milk as it enters the pasteurizer exerts an influence upon the amount that the machine can heat to a desired degree.

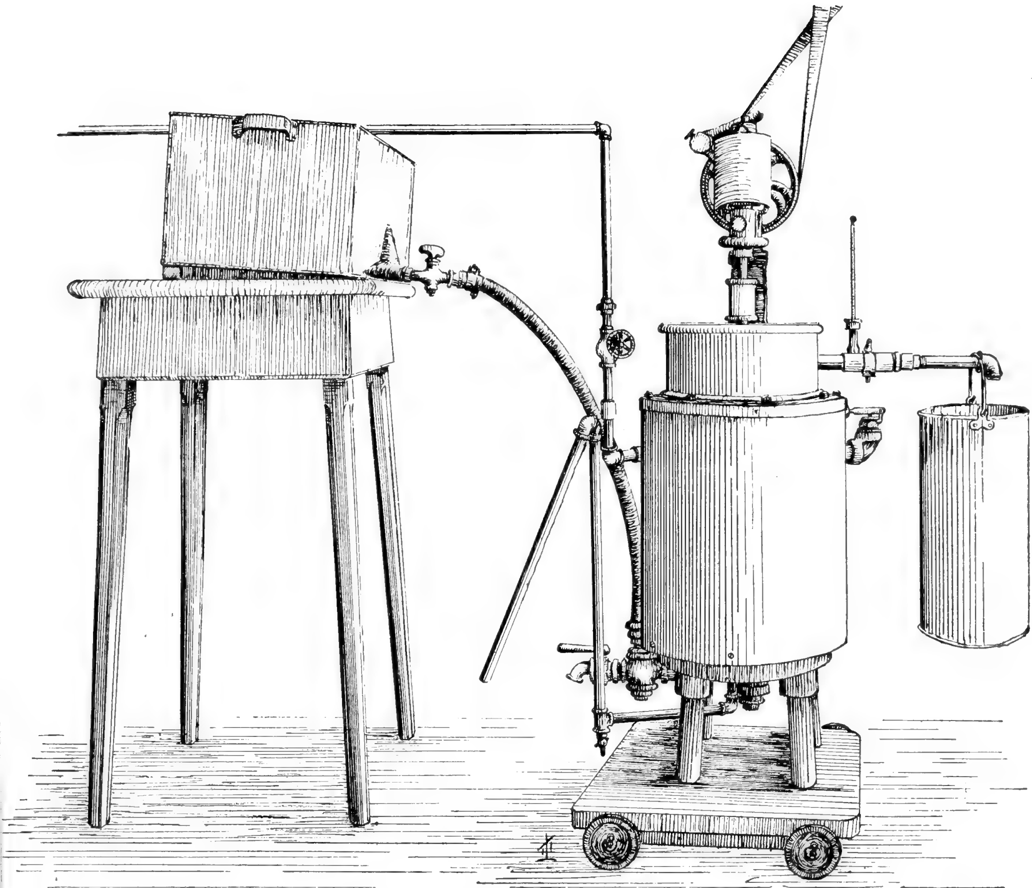

Plate III.—Arrangement of Milk Receiver and Pasteurizer.

Acidity.— As the result of experience in the pasteurization of milk by the discontinuous method it has been found impractical to attempt to pasteurize milk intended for immediate consumption when the acidity is over 0.2 per ct. calculated as lactic acid. During a considerable portion of the time our mixed milk has had an acidity above this figure.

The custom of expressing acidity in milk by percentages of lactic acid has little to recommend it other than that it is common practice. It is a well-known fact that a part of the reaction called acidity is due to the union of the alkali with the casein and that lactic acid is only one of a number of acids found in milk.

The fact always determined is the neutralization as indicated by phenolphthalien of a certain amount of normal solution of alkali. In our results this observed fact is expressed by the number of cubic centimeters of normal alkali neutralized by a litre of milk (N/L). For convenience of comparison the per ct. of lactic acid erroneously assumed from this data is given in parenthesis.

The acidity of our mixed milk ranged from 18.9 N/L (0.17 per ct.) to 40 N/L (0.36 per ct.) and during a considerable portion of the time it was above 22.2 N/L (0.2 per ct.). Thus the conditions of acidity under which the pasteurizing was done were not what would be considered ideal, but rather those which would be found in an average creamery. As the acidity of the mixed milk approached 40 N/L (0.36 per ct.) a considerable layer burned fast to the sides of the milk chamber in the pasteurizer and the accumulation in the separator bowl was increased.

On Feb. 7 the milk with an acidity of 35.5 N/L (0.32 per ct.) was pasteurized at 85° C. (185° F.) very successfully; but the next attempt with whole milk having an acidity of 40 N/L (0.36 per ct.) quickly accumulated a layer on the walls of the pasteurizer and clogged the separator bowl after passing only about 80 pounds of milk.

Steam pressure.— The pasteurizer was connected by a ¾-inch pipe directly to the high-pressure steam pipe. As will be noticed in the diagram Plate II, the steam had a free outlet at a point nearly opposite to the inlet, so that there was at no time any appreciable pressure on the pasteurizer itself. On the contrary, the steam was nearly all condensed and there was rarely any waste, even when the steam valve was opened to its full capacity.

The steam pressure given in the tables is that in the 30 horse-power boiler and was noted as one of the possible factors in the great variation in rate of operation on different days.

Rate.— The amount of milk which a pasteurizer will heat to a given temperature in a given time is important from the practical standpoint.

In order to minimize the variation in temperature to which the milk was exposed and to determine the rate more accurately, it was our custom to add water to the supply tank and when everything was running at full speed and the last of the water was leaving the tank to add the milk and note the time. After all of the milk had been added and just as the last was leaving the tank the time was again noted. The interval was taken as the time required to handle the milk. Since the amount of milk at any one time between the milk valve and the milk outlet was only about 5 pounds, the error was not great.

As one would expect, the rate varies with the pasteurizing temperature. The machine was expected to handle 2,500 pounds an hour at 70° C. (158° F.), and would do even more under favorable conditions. In our experience, it did not much exceed 2,100 at 80° C. (176° F.), and handled less at 85° C. (185° F.). It will be noticed that the rate at 80° C. ranged from as low as 900 to a little over 2,100 pounds per hour. This extreme variation is due to a number of factors, among which are variations in steam pressure and initial temperature and the cooking of the milk on to the walls of the pasteurizer. This layer of cooked material not

only acted as an insulator between the milk and the source of heat, but also encroached upon the interval between the revolving stirrer paddles and the wall, forming a rough surface along which the milk must pass. The fact that the machine was not permanently placed and lacked in rigidity was also a contributing factor to the above variations.

Pasteurizing temperature.— As soon as the milk enters the bottom of the machine it takes up heat from the steam jacket and its temperature rises to the highest point just as it reaches the milk outlet. The temperature at this point is measured by a thermometer inserted in the outlet and constitutes the so-called "Pasteurizing Temperature," although the milk really attained this degree only momentarily. As soon as the milk passes from the machine the temperature falls with a rapidity depending upon the surroundings.

TAKING SAMPLES.

The samples of unpasteurized milk were taken from the tempering vat after the milk had been thoroughly mixed. The only exception to this was during the earlier part of the work, when they were taken from the supply tank just before taking the samples of pasteurized milk from the machine.

The samples of pasteurized milk were taken from the milk outlet after sufficient had passed to remove the effect of the bacteria contained in the water used in starting the machine and in the machine itself. Care was taken to secure samples while the machine was running steadily at the desired temperature.

The samples of about 150 cubic centimeters each in sterile flasks were set into a room at 1.5° to 4.5° C. (35°–40° F.) until the pasteurization was ended, when they were taken to the laboratory on the floor above and the quantitative analyses made.

BACTERIOLOGICAL TESTS.

Method of dilution.— One c. c. of the unheated milk was added to 9 c. c. of sterile water and the two thoroughly mixed. This

process was repeated and a small fraction of a c. c. from the second dilution was added to the culture medium.

Cultures were made in Petri dishes having an internal diameter of 91-92 mm. For the sake of convenience in counting and to prevent the inhibiting effect of closely-crowded colonies, the aim was to so arrange the dilution that the growth would be about 500 colonies to the plate. In the case of the pasteurized milk, no dilution was necessary, but a measured fraction of a cubic centimeter was added directly to the nutrient media.

Media used.— The tabulated results given below were all obtained upon lactose agar made neutral to phenolphthalein with sodium hydroxide and containing 2 per ct. lactose and 1.7 per ct. agar. Agar was chosen in preference to gelatin, because in some previous work of a similar nature at the Wisconsin Station it was found that agar at 28° C. (81.5° F.) gave higher numerical results than gelatin at room temperature. Among the substances now available, there seems to be none that will call out all the individual germs when left at any one temperature.

It is not maintained by the authors that the numbers given below represent the exact number of organisms present either in the pasteurized or unpasteurized milk. All that is hoped for is that they are a close approximation and that having been taken under similar conditions may be found to be directly comparable.

Incubating temperature.— The plates were placed in an incubator at 30° C. (83° F.) and counted at the end of 48 hours. This temperature was believed to be near the optimum for the growth of most of the germs present and the time was thought to give maximum returns with a minimum amount of error. An exposure at higher temperature caused a rapid drying of the plates and one for a longer time did not usually give higher results, while the rapid spreading of superficial colonies made the counting uncertain.

Growth at room temperature required so much longer time as to complicate the work and the rapid multiplication of certain proteus forms made an accurate count very difficult.

When plates that had been kept 48 hours at 30° C. were left 3-5 days at 21° C. (70° F.) there was a small average increase on the second count. This indicates that some of the organisms present in the milk did not thrive at the higher temperature.

The above results obtained from tests upon 14 days at 70° C. (158° F.) illustrate the uncertainty of the pasteurizing action at that temperature and in this particular quite agree with the results on 15 previous days when preliminary trials were being made. They also show what misleading conclusions might be drawn when generalizations are made after one or two observations.

It should be remembered that in any heating of the milk the most desirable class of acid formers will be among the first to be killed and the residue is composed of germs not likely to improve the flavor of the butter. Just how many of this class of bacteria may be left in the milk without impairing the quality of the product, like the problem of how many weeds can be left in the field without detriment to the crop, is not clearly understood and a conservative disposition would favor their reduction to the lowest practical limits.

A most important fact shown is that 70° C. (158° F.) lies near the lower limit of the killing effect of heat applied in this way. When operating a pasteurizer in a practical way, temporary reductions of temperature are almost certain to occur, and if this reduction goes much below 70° C. the killing effect upon bacteria will be very slight.

The results of pasteurizing at 80° C. (176° F.) show a surprising reduction in the germ life and this reduction was accomplished with very slight variation on each of the 25 days tested. These 25 tests gave an average of only 117, with a maximum of 297 and a minimum of 20 living germs per c. c. in the pasteurized milk.

Comparing this average of 25 determinations made after continuous pasteurization with 6,140, the average number of germs

TABLE I.—WORKING CONDITION AND RESULTS OF CONTINUOUS PASTEURIZATION OF MILK AT 70° C.

Date.	Age of milk.	Weight of milk.	Initial temperature.	* Acidity.	Steam pressure on boiler.	Rate(Lbs. per hour)	Unpasteurized. Dilution.	Unpasteurized. Colonies on plate.	Unpasteurized. Total germs per c. c.	Pasteurized. Dilution.	Pasteurized. Colonies on plate.	Pasteurized. Total germs per c. c.	Average. Unp.	Average. Past.
	Hours.	Lbs.	Dg. C		Lbs.									
Aug. 19	....	...	..	....	.....	1776	1– 280	121	33,880	1– 8 1-3	487	4,058	41,300	4,779
	....	...	..	....	.....	....	1– 140	348	48,720	1– 5 1-5	1058	5,500	....	......
22	....	...	..	....	.....	1560	1– 270	294	79,380	1–28	1068	29,904	83,362	23,898
	....	...	..	....	.....	....	1– 135	647	87,345	1– 9 1-3	1917	17,892	....	......
23	....	...	..	....	.....	1104	1– 270	96	25,920	1–13 1-2	63	850	28,417	995
	....	...	..	....	.....	....	1– 135	229	30,915	1– 6 3-4	169	1,141	....	......
24	....	...	..	....	.....	1356	1– 270	147	39,690	1–24	507	12,168	41,512	13,032
	....	...	..	....	.....	....	1– 135	321	43,335	1–12	1158	13,896	....	......
25	....	...	..	....	.....	1434	1– 260	300	78,000	1–24	40	960	78,975	920
	....	...	..	....	.....	....	1– 130	615	79,950	1– 8	110	880	....	......
28	....	...	..	....	.....	2118	1– 250	1,950	487,500	1–26	668	17,368	442,812	17,628
	....	...	..	....	.....	....	1– 125	3,185	398,125	1–13	1376	17,888	....	......
29	....	...	..	....	.....	1872	1– 280	40,977	11,473,560	1–14	4485	62,790	11,473,560	62,790
Sept. 5	....	...	..	....	.....	2286	1– 250	21,688	5,422,000	1–24	715	17,160	5,422,000	16,878
	....	...	..	....	.....	....	....	......	....	1–12	1383	16,596	....	......
12	....	...	..	....	.....	2508	1–1250	22	27,500	1–62	258	15,996	23,237	15,936
	....	...	..	....	.....	....	1– 575	33	18,975	1–42	378	15,876	....	......
26	....	...	..	....	.....	1266	1– 480	40	19,200	1–26	49	1,274	38,400	1,096
	....	...	..	....	.....	....	1– 240	240	57,600	1–17 1-3	53	918	....	......
Dec. 30	36–24	367	21	21.5	65–45	2934	1– 300	66	19,800	1–14	21	294	27,900	287
	12–4	...	..	(0.193 %)	.....	....	1– 150	240	36,000	1–28	10	280	....	......

Jan.	2	48–36	494	20	20	40–55	1740	1– 383	41	15,708	1–25	2	50	19,814	120
		24–12–4	...	..	(0.18 %)	.....	....	1– 230	104	23,920	1– 5	38	190	....	......
Feb.	2	36	364	25	25	60–60	2424	1–4200	124	520,800	1– 5	3250	16,250	637,350	17,062
		24–12	...	..	(0.20 %)	.....	....	1–2100	359	753,900	1– 2 1-2	7150	17,875	....	......
	5	36	388	27	26	65–60	2328	1–2000	2,697	5,394,000	1–26	2275	59,150	5,703,000	38,615
		24–12	...	..	(0.23 %)	.....	....	1–1000	6,012	6,012,000	1– 5 1-5	3477	18,080	....	......

* The upper figures in each space indicate number of cubic centimeters of normal alkali required to neutralize 1 liter of milk, as explained on p. 139; figures in parentheses indicate percentage of lactic acid, as ordinarily calculated.

TABLE II.— WORKING CONDITION AND RESULTS OF CONTINUOUS PASTEURIZATION OF MILK AT 80° C.

Date.	Age of milk.	Weight.	Initial temperature.	Acidity.*	Steam pressure on boiler.	Rate per hour.	Unpasteurized. Dilution.	Unpasteurized. Colonies on plate.	Unpasteurized. Germs per c. c.	Pasteurized. Dilution.	Pasteurized. Colonies on plate	Pasteurized. Germs per c. c.	Average germs per c. c. Unp.	Average germs per c. c. Past.
	Hours.	Lbs.	Deg C.		Lbs.	Lbs								
Sept. 27	12–4	206	13	....	.....	1122	1– 500	134	67,000	1–28	9	252	69,500	217
	....	...	..	....	.....	....	1– 250	288	72,000	1–14	13	182	....	...
28	12–4	168	12	....	.....	1680	1– 520	16	8,320	1–6 1-2	11	71	10,010	61
	....	...	..	....	.....	....	1– 260	45	11,700	1–4 1-3	12	52	....	...
Oct. 2	36–24	401	12	....	.....	1266	1– 366	141	51,606	1–6	5	30	42,573	25
	12–4	...	..	....	.....	....	1– 183 1-3	183	33,540	1–4	5	20	....	...
4	36–24	381	8	....	65–50	1632	1– 250	40	10,000	1–3 2-9	18	58	9,583	46
	12–4	...	..	....	.....	....	1– 416 2-3	22	9,166	1–2	17	34	....	...
6	36–24	382	10	....	35–33	1206	1– 157	126	19,782	1–2	10	20	18,191	21
	12–4	...	..	....	.....	....	1– 100	166	16,600	1–1	22	22	....	...
7	12–4	191	15	....	45–40	1636	1– 460	23	10,580	1–2	11	22	11,960	25
	....	...	..	....	.....	....	1– 460	29	13,340	1–1	28	28	....	...
9	36–24	364	12	....	40–30	1320	1– 300	121	36,300	1–2	20	40	38,100	36
	12–4	...	..	....	.....	....	1– 150	266	39,900	1–1	33	33	....	...
11	36–24	322	10	....	30–30	1248	1– 300	98	29,400	1–2	20	40	30,150	29
	12–4	...	..	....	.....	....	1– 150	206	30,900	1–1	18	18	....	...
13	36–24	326	13	....	60–65	1626	1– 300	41	12,300	1–2	13	26	15,750	20
	12–4	...	..	....	.....	....	1– 200	96	19,200	1–1	15	15	....	...
16	36–24	361	16	....	30–35	1272	1– 367	196	71,932	1–2	49	98	68,906	79
	12–4	...	..	....	.....	....	1– 183	360	65,880	1–1	61	61	....	...
18	36–24	323	17	....	45–55	1380	1– 400	82	32,800	1–2	31	62	47,300	51
	12–4	...	..	....	.....	....	1– 200	309	61,800	1–1	41	41	....	...
20	36–24	345	15	....	35–40	1146	1– 350	500	175,000	1–2	134	268	202,100	255
	12–4	...	..	....	.....	....	1– 150	1,528	229,200	1–1	243	243	....	...

23	36–24	338	15	....	50–55	1194	1– 230	1,200	276,000	1–2	49	98	313,222	98
	12–4	...	..	....	.....	....	1– 383	915	350,445	1–1	97	97	....	...
Dec. 13	36–24	361	15	23.5	60–50	1272	1–1150	57	65,550	1–2	119	238	61,650	222
	12–4	...	..	(0.21 %)	.....	....	1– 350	165	57,750	1–1	207	207	....	...
18	36–24	370	22	53	60–45	924	1– 400	41	16,400	1–3	62	186	19,000	210
	12–4	...	..	(0.298%)	.....	....	1–1200	18	21,600	1–2	117	234	....	...
20	36–24	331	26	20	50–65	1200	1– 150	100	15,000	1–3	69	207	15,000	190
	12–4	...	..	(0.18 %)	.....	....	......	......	....	1–2	87	174	....	...
26	48–36	468	25	20	55–52	948	1– 432	58	25,056	1–2.8	102	285	26,352	255
	24–12–4	...	..	(0.18 %)	.....	....	1– 216	128	27,648	1–2	113	226	....	...
28	36–24	376	21	18.5	60–20	900	1– 416	34	14,144	1–3	45	135	12,447	123
	12–4	...	..	(0.17 %)	.....	....	1– 250	43	10,750	1–2	56	112	....	...
Jan. 4	36	362	25	21	60–62	1890	1– 230	2,649	609,270	1–3	25	75	....	...
	24–12–4	...	..	(0.19 %)	.....	....	1– 383	1,462	559,946	1–6	7	42	584,608	58
6	36–24	320	25	....	65–65	1920	1– 575	2,166	1,245,450	1–2	29	58	....	...
	12–4	...	..	....	.....	....	1–1150	3,169	3,644,350	1–3 1-4	28	91	2,444,900	74
8	36–24	387	25	21	60–65	2108	1–2100	1,220	2,562,000	1–4	24	96	....	...
	12–4	...	..	(0.19 %)	.....	....	1– 700	3,330	2,331,000	1–2	55	110	2,446,500	103
10	36–24	338	26	....	40–40	2136	1–2100	991	2,081,100	1–4	28	112	....	...
	12–4	...	..	....	.....	....	1– 700	2,652	1,856,400	1–2	40	80	1,968,750	96
13	36–24	387	25	26.5	40–40	1716	1–2100	350	751,800	1–3	94	282	....	...
	12–4	...	..	(0.24 %)	.....	....	1–1050	733	769,650	1–2	156	312	760,725	297
15	36–24	304	25	....	60–65	1824	1–2200	709	1,559,800	1–3	69	207	....	...
	12–4	...	..	....	.....	....	1–1100	1,285	1,413,500	1–2	79	158	1,486,650	182
17	36–24	307	26	36	40–40	1602	1–2000	38,415	76,830,000	1–4	43	172	....	...
	12–4	...	..	(0.32 %)	.....	....	1–2000	38,677	77,354,000	1–2	45	90	77,092,000	131

* See foot note, Table I.

per cu. cm. found by Dr. H. L. Russell[6] in 50 samples of milk pasteurized by the discontinuous method for direct consumption, the surprising thoroughness of this continuous pasteurization at 80° C. will be understood.

Were it not for the fact that in the present state of our knowledge it is believed that a heating of milk to 85° C. (185° F.) in a continuous pasteurizer is necessary to remove all danger of tuberculosis, the use of 80° C. in pasteurization for butter-making, at least in this special machine, would leave little to be desired.

Confining our attention to the number of germs found in the pasteurized milk, the results of the above tests show that there is practically no increase in efficiency in passing from 80° C. to 85° C. If we can be allowed to generalize on so narrow a basis as seven determinations the gain comes in an increased regularity in the reduction of the number of germs present. There is also a practical advantage in working at a temperature well above that at which an active germ-killing effect begins.

The strongest argument in favor of 85° C. (185° F.) lies in the fact that it is the lowest one that we can use and feel assured that we have removed the danger of returning germs of tuberculosis along with the mixed skim milk from the factory. Leaving out of account all relation of this disease to the human family, its effect upon our calves and pigs is one that we cannot afford to ignore.

While it does not come within the province of this bulletin to discuss the effect of heating upon the butter, it will not be out of place to state that, even with cream from milk which had been heated to 85° C., butter was made in which no cooked flavor could be detected when coming from the churn. While our efforts were not universally so successful, still, in the cases where such a flavor was noticeable at churning, this disappeared after a few hours standing. The experience of this Station, so far as it goes, is quite in accord with that of Dr. Storch, who states that whole milk can be heated to 90° C. without any permanent injury to the flavor of the butter.

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[6] Ann. Rept. Wis. Agr. Exp. Sta., 1895, p. 159.

TABLE III.— WORKING CONDITION AND RESULTS OF CONTINUOUS PASTEURIZATION OF MILK AT 85° C.

Date.	Age of milk.	Weight.	Initial temperature.	Acidity.*	Steam pressure on boiler.	Rate per hour.	Unpasteurized. Dilution.	Unpasteurized. Colonies on plate.	Unpasteurized. Total germs per c. c.	Pasteurized. Dilution.	Pasteurized. Colonies on plate.	Pasteurized. Total germs per c. c.	Average. Unp.	Average. Past.
	Hours.	Lbs.	Deg. C.		Lbs.	Lbs.								
Jan. 19	36–24	392	28	31	60–62	978	1–2200	23,422	51,528,400	1–3	16	48	....	...
	12	...	..	(0.28 %)	.....	....	1–1100	......	....	1–2	26	52	51,528,400	50
22	36–24	404	24	26	62–45	1860	1–2200	9,620	21,164,000	1–3	27	81	....	...
	12	...	..	(0.23 %)	.....	....	1–1100	24,830	27,313,000	1–2	42	84	24,238,500	83
24	36–24	362	34	27.5	60–60	1974	1–2100	11,284	23,696,400	1–4	16	64	....	...
	12	...	..	(0.24 %)	.....	....	1–2100	7,020	14,742,000	1–2	26	52	19,219,200	58
26	36–24	370	26	....	55–35	1584	1–4400	4,264	18,761,600	1–4	61	244	....	...
	12	...	..	....	.....	....	1–2200	7,410	16,302,000	1–2	112	224	17,531,800	234
29	36–24	361	25	27.5	60–60	1694	1–4200	2,671	11,218,200	1–3	32	96	....	...
	12	...	..	(0.24 %)	.....	....	1–2100	10,135	21,283,500	1–2	35	70	16,250,850	83
31	36–24	353	30	27.5	65–60	1410	1–4200	118	495,600	1–4	50	200	....	...
	12	...	..	(0.24 %)	.....	....	1–2100	262	550,200	1–2	106	212	522,900	206
Feb. 7	36–24	350	25	35.5	65–65	1314	1–4800	11,830	56,784,000	1–4 1-4	18	76	....	...
	12	...	..	(0.319%)	.....	....	1–2400	17,310	41,544,000	1–2	44	88	49,164,000	82

* See foot-note, Table I.

REPORT

OF THE

Department of Botany.

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REPORT OF THE BOTANIST.

LEAF SCORCH OF THE SUGAR BEET, CHERRY, CAULIFLOWER AND MAPLE.*

F. C. STEWART.

SUMMARY.

In central New York the foliage of sugar beets, cherries, Norway maples and sugar maples has been scorched by excessive transpiration. On Long Island cauliflower has been similarly affected. Plants standing in dry, sandy soil have suffered most.

With the sugar beet, the leaves blacken and die. In severe cases the plant is killed outright, but generally the affected plants revive and make a second growth. The affected roots are small, frequently discolored, and poor in sugar.

With the cherry, part of the foliage, often as much as three-fourths, becomes brown and dead. The variety Montmorency Ordinaire is the one most commonly affected. This trouble has been common in the vicinity of Geneva the present season and is said to have occurred in one orchard quite severely in 1898, without, however, affecting the crop of 1899.

With the cauliflower, the tips of young leaves turn brown, as if frosted. This occurred quite commonly in eastern Long Island during August, but did little damage.

The foliage of Norway and sugar maples is much subject to injury from excessive transpiration. The leaves become light brown or reddish brown. Nursery trees and those recently transplanted suffer most, but large shade trees are not exempt. Little permanent injury is done except to newly-set trees.

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* Reprint of Bulletin No. 162.

With all of these plants the trouble is not due to a gradual drying, but to a sudden scorching by the transpiration of more water from the leaves than the roots are able to supply.

INTRODUCTION.

It is not an uncommon thing for the foliage of various plants to be injured by excessive transpiration. Such injury may be brought about in either of two ways: (1) By a process of gradual drying, such as occurs in plants suffering from drought, and (2) By sudden scorching, as when a fire is built under a tree. With the first kind of injury every one is familiar and those living in the arid and semi-arid portions of our country have frequently observed the latter kind. In Kansas, for example, dry, hot southwest winds often ruin promising crops of corn in two or three days.

But here in the East, the sudden scorching of foliage by hot wind and sun is of such rare occurrence that it attracts attention and is generally misunderstood by farmers and fruit growers. It is frequently mistaken for infectious disease. The object of this bulletin is to place upon record some observations on the sudden scorching of the foliage of sugar beet, cherry, cauliflower and maple, due to excessive transpiration.

LEAF SCORCH OF SUGAR BEET.[1]

About the middle of August, 1899, some farmers in Yates and Ontario counties wrote to the Station that their sugar beets were blighting. On August 29, the writer visited several of the affected fields and found the so-called blight to be characterized as follows: On slightly affected plants the only indication of disease was to be seen in the brown or black, dead leaf margins. In more severe cases the young leaves at the center of the crown were black and dead, as were also the blades of most of the leaves. Many plants showed nothing green but the petioles of the larger

[1] For the illustrations used in this bulletin, the author is indebted to Mr. F. H. Blodgett, Assistant Botanist and Entomologist.

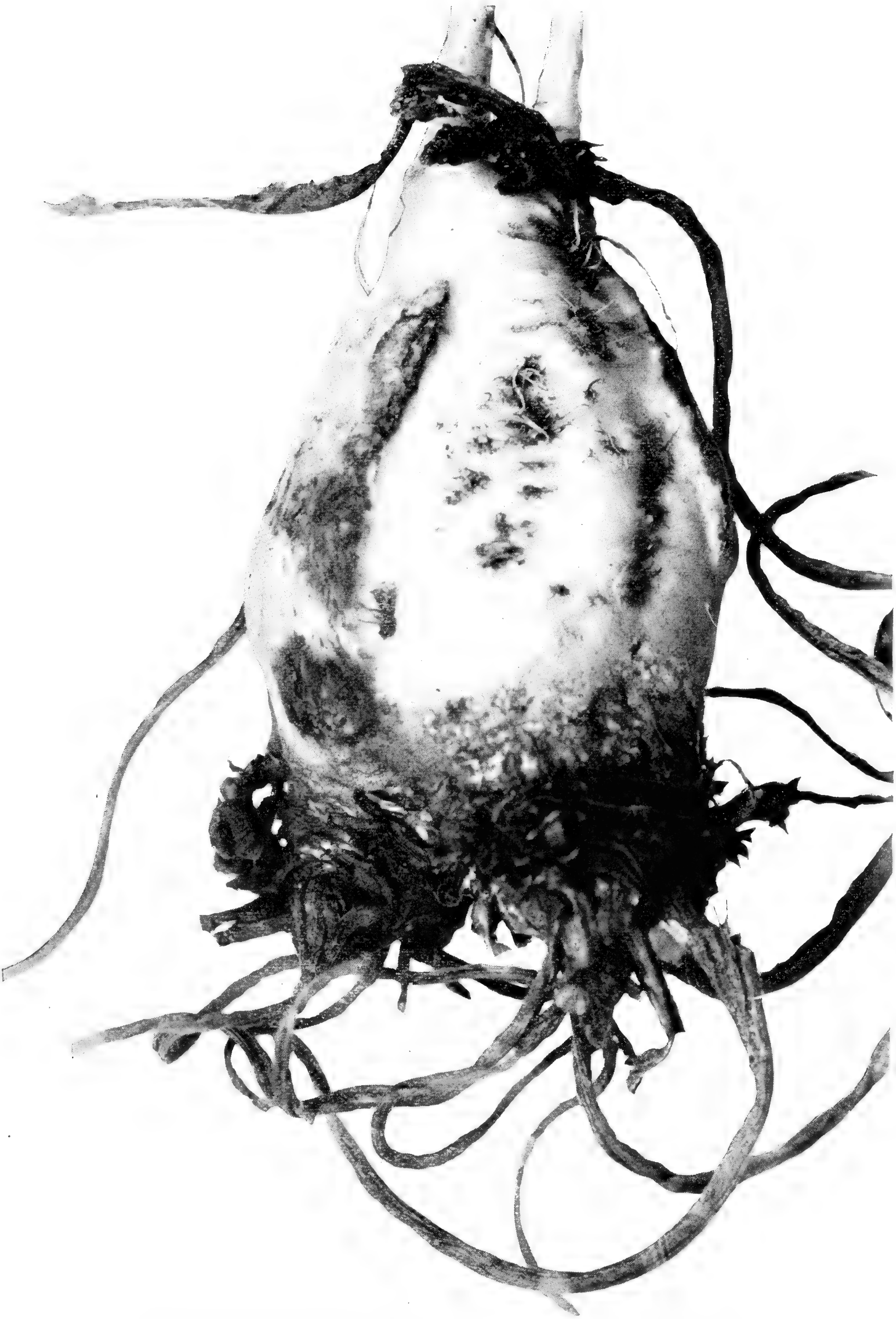


PLATE IV.—SUGAR BEET KILLED BY LEAF SCORCH. EARLY STAGE.

PLATE V.—SUGAR BEET KILLED BY LEAF SCORCH. MIDDLE STAGE.

leaves. In the petioles of the dead leaves the fibro-vascular bundles were not blackened except, perhaps, for a short distance below the blackened blade. In the majority of cases the roots appeared normal, but the plants most severely attacked often showed a brown discoloration of the root. This discoloration extended from the outside toward the center for a distance of from one-fourth to one-half an inch. The discolored tissue showed no indication of rot and was separated from the healthy tissue by an indefinite and somewhat irregular line. (See Plate VIII.) The fibro-vascular bundles colored somewhat more deeply than the parenchyma, giving a zonate appearance to the affected tissue. The location of the affected tissue could generally be determined before the root was cut open, by the darker color and pronounced elevation of the bark. (See Plates IV and V.) In some cases when an affected root was cut cross-wise just below the crown the fibro-vascular bundles were found to be much blackened, but this character was by no means a constant one.

For a time the writer was puzzled to account for this condition of the beets. The first hint of the true nature of the trouble was obtained from observations made on a field of beets owned by Mr. Clark Crozier, near Halls. This field was level and the soil a sandy loam, with the exception of a small knoll which rose abruptly near the center of the field and consisted of very light, sandy soil. The beets on this sandy knoll were diseased, while those on all the rest of the field were in perfect health. This indicated that lack of water was the cause of the trouble. A severe drought was prevailing at the time and naturally the plants first affected would be those standing in dry, sandy soil. Further observations showed that the beet blight occurred chiefly upon light, sandy soil; but a field near Stanley furnished an exception to the rule. This field, which contained about eight acres, consisted principally of sandy loam, which might be expected to resist drought better than many other fields in the vicinity. As a matter of fact, it was considerably blighted, not uniformly, but over irregular areas, although

the soil appeared to be absolutely uniform. However, it should be stated that the blight was most severe along one margin of the field where the ground began to rise a little. The owner of this field stated that early in the season there came heavy rains, which prevented cultivation for a few days. In the meantime the plants became so large that it was decided not to cultivate them any more. The drought then began. The soil became hard and cracked and consequently parted with its moisture more rapidly that it would if it had been cultivated after the rains as were other fields in the neighborhood. The loss of water was still further accelerated by the unusually luxuriant growth of leaves, which was the result of a high state of fertility of the soil.

At the time of our first visit to this field, August 29, it was observed that many of the affected plants had thrown out new leaves at the center of the crown. We thought this to be the result of a light shower[2] which fell August 27, and predicted that growth would very soon be checked unless more rain fell. We were accordingly surprised to find upon our second visit, September 12, that the blight had made no progress. On the contrary, most of the affected plants were putting out young leaves at the crown. (See Plate VII.) On many plants an entirely new crops of foliage had appeared during the previous two weeks. Plants which were apparently dead two weeks before were now green with a crown of new leaves; and this in spite of the fact that there had been no rain worth mentioning[3] since our former visit. All other affected fields showed similar improvement. A few of the worst affected plants were dead, but the majority were making a second growth. It now became evident that this beet blight was not a gradual drying of the foliage

2 At Penn Yan, .36 inch; at Geneva, .26 inch.

3 The actual precipitation was as follows:

At Penn Yan. Sept. 1, 1.07 in.; Sept. 3, trace; Sept. 5, trace; Sept. 8, .23 in.; Sept. 11, .09 in.

At Geneva. Sept. 1, .10 in.; Sept. 2, trace; Sept. 5, trace; Sept. 8, .07 in.; Sept. 11, .04 in.

PLATE VI.—SUGAR BEET KILLED BY LEAF SCORCH. ADVANCED STAGE.

PLATE VII.—SECOND GROWTH OF SUGAR BEET FOLIAGE.

due to a gradual decrease in the supply of water in the soil, but that it had been brought about suddenly. Some time during the first two weeks in August, probably about August 9, the weather conditions (temperature, humidity and wind) had been such that the quantity of water transpired by the leaves was greater than the roots were able to supply. As a result the leaves were scorched. Then, with the passing of the conditions which induced excessive transpiration, the roots were again able to meet the demands for moisture thereby enabling the plants to resume growth, although the soil was drier than at the time the injury occurred.

It has already been stated that some of the plants were killed outright. Upon a third visit to the affected field at Stanley, made October 24, it was observed that these dead roots were still sound except for brown, mostly V-shaped, scab-like areas upon the upper portion of the root. These brown areas represent the later stage of the raised, discolored areas observed on August 29. The tissue was decayed to a depth of from one-eighth to one-quarter of an inch and had been quite generally eaten away by millipedes, leaving cavities where in the earlier stage of the disease there had been elevations. (See Plate VI.) Underneath the affected areas the sound tissue showed the same light brown discoloration as on August 29. It seemed to have progressed, but little, if any. Sometimes the browning occurred in the central portion of the root, but usually it was found only around the circumference and almost always in the form of concentric rings. In the field at Stanley the dead roots quite generally showed the light brown discoloration of sound tissue, but in an affected field at Bellona it was a common thing to find bad cases of the disease in which there was little or no internal browning.

The plants which survived made a considerable growth of new foliage. The roots of such plants did not commonly show any discoloration or decay, but, strange to say, they averaged considerably smaller than the roots of plants which had been killed outright. This indicates that the plants which were the largest

and thriftiest at the time of the injury were the ones most severely affected; and, further, that during two months of second growth the surviving plants increased the size of their roots but little.

That the discoloration of the root is a physiological effect (the result of the death of the foliage) rather than the work of any parasitic organism is shown by the results of the following inoculation experiment: After the dirt around five healthy sugar beets had been removed there was cut from each a pyramidal cavity one-fourth inch square at the surface and one-half inch deep. These cavities were then filled with similarly shaped plugs of the discolored beet root, the whole covered with grafting wax and the dirt replaced. Five check beets were treated in the same manner except that the cavities were filled with plugs of healthy beet. This was done August 30. On October 18 the beets were pulled and cut open. The inoculated beets showed no discoloration of tissue except a slight blackening around the wounds, which was no greater than in the check roots.

Some farmers thought that the beet disease was much worse on land where cabbages were affected by black rot in the season of 1898, but our own observations show that there is not good foundation for such belief. It can be stated positively that there is no connection between the leaf scorch of beets and the black rot of cabbage.

The amount of damage done to the beets was considerable. Although the majority of the plants recovered, the roots were smaller than they otherwise would have been and their sugar content was lower. Analyses made by Mr. J. A. LeClerc, Assistant Chemist, gave the following results: (1) Roots of plants killed outright analyzed 5.9 per ct. of sugar (in the juice) with a coefficient of purity of 61.6; (2) Roots of plants which had made a second growth after having all their foliage killed analyzed 10.7 per ct. of sugar, coefficient of purity, 73.6; (3) Roots of uninjured plants growing within a few feet of the diseased plants analyzed 15.2 per ct. of sugar, coefficient of purity, 80.3.

The only other beet leaf disease with which leaf scorch is likely to be confused is a fungus disease known as leaf spot.[4] This is a common and destructive disease of beets in New York State and is more prevalent in wet seasons than in dry. It forms circular, brown or gray dead spots on the leaves. If the spots are numerous a part or the whole of the leaf may die and turn black in a manner closely resembling leaf scorch, but in such cases the outlines of the spots are plainly visible until the leaf is fully decayed.

In the advanced stage, the effects of leaf scorch on the beet root might easily be mistaken for scab. In general, it may be distinguished from scab by the light brown discoloration of the sound tissue but when the brown discoloration is absent the diagnosis must be based chiefly upon the shape and location of the affected areas. In leaf scorch the affected areas occur principally upon the upper portion of the root and are usually more or less V-shaped with the opening toward the crown; whereas, in scab the spots occur on any part of the root and are more often irregular or circular than V-shaped.

Concerning treatment it is needless to say that proper irrigation is a sure preventive; but where irrigation can not be practiced avoid planting on light, sandy soil and in dry weather conserve the moisture by stirring the soil frequently and especially after every shower.

LEAF SCORCH OF CHERRY.

Late in September of the present year a Geneva fruit grower called our attention to a scorching of cherry foliage which he feared might be an infectious disease like the fire blight of the pear and apple. On trees of all ages more or less of the foliage was brown, crisp and dead. The dead leaves remained attached to the twigs which were neither blackened nor shriveled. A

[4] For an account of beet leaf spot and scab and their treatment, see Cornell Exp. Sta. Bul. 163. Three Important Diseases of the Sugar Beet.

brief study of this disease convinced us that we had here to do with a trouble similar to the leaf scorch of beets. Like the beet disease it was most severe on trees standing in dry soil. Upon inquiry among fruit growers it was found to be of common occurrence this year.

The worst case of the disease which has come under our observation occurred in an orchard belonging to Maxwell Bros. near Geneva. This orchard contained 715 Montmorency cherry trees about eleven years of age, the trunks having a diameter of from four to five inches. The trees were set fifteen feet apart each way. Over the whole orchard the soil was uniform and had been thoroughly cultivated. It consisted of a light clay underlaid with slate at a depth of from eighteen inches to two feet. The orchard was located on a gentle eastern slope and was closely surrounded upon all sides by other fruit trees.

On October 4 each tree in the orchard was examined and an estimate made of the amount of foliage affected. The result was as follows:

1	tree, 100 per cent. of the foliage affected.
637	trees, 75 to 85 per cent. of the foliage affected.
57	trees, 50 per cent. of the foliage affected.
13	trees, 25 per cent. of the foliage affected.
5	trees, 5 per cent. of the foliage affected.
2	trees, not affected.
715	

It is an interesting fact that although six-sevenths of all the trees in the orchard showed 75 per ct. or more of the foliage affected there was but a single tree upon which all of the foliage was killed. The trees were affected with remarkable uniformity. The worst affected trees stood in no particular part of the orchard but were scattered all through it. Although it frequently happened that one side of a tree would be severely attacked while the other half was entirely exempt, there was no uniformity as to the side attacked; it was quite as often the north side as any

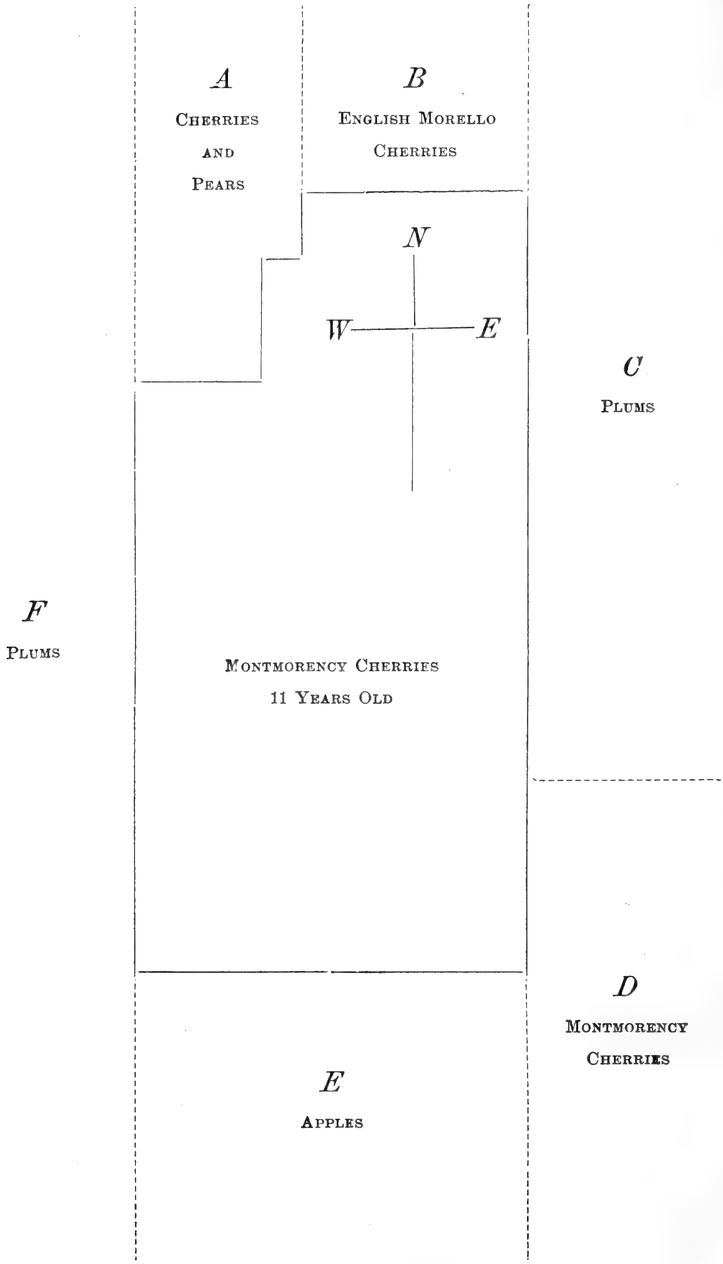
Plate VIII.—Cross Sections of Sugar Beets Killed by Leaf Scorch.

other. Usually, the affected branches were scattered all through the top. Lateral branches were more apt to be affected than main or leading branches, but there were some exceptions even to this rule. If any part of a leaf was affected the whole of it was affected, with very few exceptions. The majority of the affected leaves were still hanging upon the twigs on October 4, but they showed a tendency to fall somewhat earlier than the healthy leaves. The twigs were plump and outwardly normal. The cortex was green and apparently normal, but the sapwood was slightly discolored. This discoloration was most pronounced on twigs of the present season's growth, but was noticeable all along the branch.

The foreman in charge of the orchard states that the disease appeared rather suddenly, although not quite all at once and that it occurred about August 20. The orchard was affected in a similar manner in 1898, but not so severely. In 1898 the scorching appeared in July before picking was all done and it was feared that the following crop would be considerably lighter because of it. However, such was not the case. The crop of 1899 was a heavy one and there were no visible effects of the scorching of the foliage the previous summer. This orchard was also slightly affected in 1897.

It appears that cherries are much more liable to this sort of injury than are pears, plums or apples. Scattered through the affected cherry orchard there were a few small pear trees which had been planted to replace dead cherry trees. None of these pears showed any sign of leaf scorch; neither did the pears located at A (see Plan) on the same kind of soil. Plum trees at C and F immediately adjoining the diseased cherries were in perfect health. The several different varieties of apples at E were also unaffected. The English Morello cherries at B were considerably affected but not so severely as the Montmorencies. The Montmorency orchard at D was composed of young trees and situated upon moister and deeper soil. However, a good

many trees were slightly affected, especially those standing in the corner of the orchard near the old Montmorency orchard.



Plan of Maxwell's Cherry Orchard affected with Leaf Scorch.

In no other orchard examined have the trees been so uniformly affected as in this one; perhaps because in no other case have the soil and conditions been so uniform. In general, trees affected in varying degrees up to one-half of the foliage have been found freely intermingled with perfectly healthy trees; but when an orchard was situated partly on dry and partly on moister soil, the disease was invariably worst on the trees standing in the dry soil.

In one orchard of large trees of Montmorency the disease was confined chiefly to the lower branches. A cherry grower at Hector states that in his orchard the trees were generally affected upon the south side, but in the orchards about Geneva we have not observed that the south side of the tree is more often affected than any other side. Trees standing in exposed situations have been no more affected than sheltered trees.

As to the time the injury occurred there is a difference of opinion among fruit growers. Some believe that the injury came on gradually, but the majority are of the opinion that it occurred within a comparatively short space of time. Some say it occurred early in August, others about the middle of August and one is certain that his orchard was not affected until the first week in September. It is not improbable that there were two periods when the weather conditions were favorable to the scorching of foliage. One occurred some time during the first half of August and the other on Sunday, September 3. On the latter date the temperature was high, the air dry and a strong wind blowing. The writer expected much injury to result from this, but observed none whatever. Nevertheless, cherries in some situations may have been injured.

Some have attributed leaf scorch to over-bearing, but there is no evidence to support this theory. In many cases trees which have never borne fruit have been severely affected. It is possible that fruit-bearing tends to increase the liability to the disease, but even that remains to be proven.

Accurate information is lacking as to the susceptibility of different varieties. Montmorency[5] has been more commonly affected than any other variety, but English Morello and some other varieties have shown it to a considerable extent.

From the experience of Maxwell Bros., it would appear that little harm is likely to result from this scorching of the foliage, but it seems incredible that a cherry tree can lose a large part of its foliage in July or August without affecting its productiveness. The effect must be the same as if the leaves were removed at this time. We shall watch the Maxwell orchard with interest the coming season.

LEAF SCORCH, OR TIP BURN, OF CAULIFLOWER.

On September 1 Mr. F. A. Sirrine, Entomologist at our Branch Office on Long Island, sent to the Station some cauliflower leaves the margins of which were blackened and shriveled. The diseased leaves were accompanied by a letter saying that throughout eastern Long Island the partly unfolded leaves of cauliflower were quite generally affected in this manner. On September 7, in company with Mr. Sirrine, the writer visited some of the affected cauliflower fields in the vicinity of Mattituck. At this time the affected leaves were growing and appeared normal except for their crisp, brown or black margins. The newest leaves were entirely free from the trouble showing that the cause of the blackening was not then active. It was quite plainly another case of leaf scorch.

Large plants were more severely injured than small ones. The worst affected field observed was one in which the plants were very large and thrifty and had commenced to form heads.[6]

As with the beet and cherry, the exact time the injury occurred is unknown. It occurred some time during the last ten days of August. Although the rainfall for August in this section was

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5 The Montmorency grown at Geneva is Montmorency Ordinaire.

6 Cauliflower was not generally heading at this date, September 7.

very light (.75 inch at Cutchogue) there was considerable fog. Mr. Sirrine states that there was continuous fog from August 18 to 20, inclusive, and some each day for a week following this period, but no rain fell between August 13 and 31. It is our opinion that the injury was caused by the hot sun falling upon young leaves which were unusually tender because of having grown in foggy weather.

Tip burn should not be confused with the bacterial disease called black rot[7] of cauliflower, cabbage and related plants. Both diseases may occur in the same plant, but many plants affected with tip burn show no blackening of the fibro-vascular bundles — the most reliable diagnostic character of the black rot. Tip burn affects the margins of the young leaves, while black rot attacks chiefly the old leaves and when it does occur on young leaves shows itself throughout the whole leaf rather than at the margin.

The amount of damage done by tip burn of cauliflower has been small.

LEAF SCORCH OF NORWAY AND SUGAR MAPLES.

The Norway maple, *Acer platanoides,* is much subject to injury from excessive transpiration. In New York more or less of it occurs nearly every season. It is most common on recently transplanted trees, but very frequently occurs on rapidly growing nursery stock and in very dry seasons may be observed also upon large shade trees. During the past season this maple leaf scorch has been been unusually common. Besides attacking the Norway maple it has been common on the sugar maple, *Acer saccharinum.* In the course of a half day's drive in Central New York during last August or September one might see along the roadside, perhaps, a hundred or more sugar and Norway maples on which more than half of the foliage was brown Many slightly affected trees would also be seen.

[7] *Pseudomonas campestris* (Pammel) Smith.

If the injury is severe and occurs before the leaves are fully grown,[8] the injured leaves fall and new ones appear, but if the injury occurs after the leaves are full grown they remain attached to the twigs until late in autumn. In the latter case some of the leaves will be found wholly dead, but the majority of them will show a dead, brown portion and a living, green portion. As a rule, especially on the sugar maple, the dead portion is located around the margin of the leaf (see Plate IX, fig. A), but it may occur in the form of circular or irregular blotches; or the margin of the leaf may be occupied by living, green tissue surrounding a dead area at the center (see Plate IX, fig. B). In all cases the living tissue is separated from the dead by a sharply defined line. The color of the dead tissue is either light brown or reddish brown. The injured leaves for the most part remain expanded.

As with the beet, cherry and cauliflower, this injury to maple foliage occurs in a comparatively short space of time. It happens whenever the quantity of water transpired by the leaves is greater than that which the roots are able to supply; and this condition of things may be brought about in several ways. Some of the factors which enter into the problem are: Area of leaf surface exposed, quantity of water in the soil, activity of the roots, and location of the tree as regards exposure to wind. Having in mind these several factors, it is easy to understand how one tree may be seriously injured while another tree standing close beside it may not be affected at all. This is of common occurrence.

In nurseries the disease often escapes notice until the dead leaves have become overgrown with various saprophytic fungi which are likely to be mistaken for the cause of the trouble.

Trees recently transplanted may die from the effects of leaf scorch, but established trees rarely show any permanent injury.

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[8] Observations upon the scorching of immature maple foliage have been reported by Stone, G. E., and Smith, R. E. Wilt of Maple Leaves. Ninth Ann. Rept. Hatch Exp. Sta., of Mass. Agr. Coll.: 81–82; also by Stewart, F. C. Norway Maples Injured by Dry Winds. Fifteenth Ann. Rept. of this Station: 453–454.

There is a fungous disease of the Norway maple which might be mistaken for leaf scorch by one unfamiliar with the latter trouble. This is an anthracnose[9], *Gloeosporium apocryptum* E. & E., which attacks the leaves and young shoots. It is most severe on small trees, especially nursery trees, occurring but rarely on large shade trees. It attacks chiefly the terminal shoots, often transforming them into much branched "heads." The leaves are dwarfed and have a yellowish green color, with the margins curled downward and blackened as if slightly frosted. This disease is prevalent in Long Island nurseries and has been observed at Geneva the present season on nursery trees and small shade trees.

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9 See Fourteenth Ann. Rept. N. Y. Exp. Sta., 1895: 531–532.

NOTES ON VARIOUS PLANT DISEASES.*

F. C. STEWART.

SUMMARY.

I. During the season of 1898 a bacterial rot caused heavy losses to the onion growers in Orange Co., N. Y. The onions were found to be affected at harvest time. One or more layers of the onion would be soft rotten while the adjacent layers were sound. Sometimes the rotten layers were on the interior, in which case the affected bulbs might be difficult of detection; or the rot might be confined to the outermost fleshy layer, producing the so-called slippery onions. Although this rot is quite certainly due to bacteria, it is not readily produced by inoculation with diseased tissue except in the presence of water. This shows that water is an important factor in the rot and that the unusually large amount of rot in 1898 was due to the excessively wet weather which occurred in July and August of that year. Thorough drainage and clean cultivation are recommended as preventive measures.

II. Leaves of field cucumbers affected with a powdery mildew have been received from Athens, Pa. This is believed to be the first record of the occurrence of powdery mildew on field-grown cucumbers in America. In greenhouses it is not uncommon. The identity of the fungus is uncertain, but it is probably different from the powdery mildew occurring on squashes and pumpkins.

III. A dodder, *Cuscuta gronovii* Willd., has occurred on greenhouse cucumbers at the Station. Plants affected with this parasite should be immediately destroyed to prevent it from spreading. It is very aggressive.

* Reprint of Bulletin No. 164.

IV. The disease of Baldwin applies, known in New York as the Baldwin fruit-spot, is characterized by small brown sunken spots which occur on the fruit about the time it is gathered. Underneath the spots the tissue is light brown and spongy. The diseased tissue contains no fungus hyphæ. In moist chamber the spots do not enlarge and no fungus appears on them. On various culture media the affected tissue produces no growth. The conclusion is that the disease is not caused by fungi or bacteria. However, the work of other investigators indicates that similar spots on the Baldwin and other varieties may be due to parasitic organisms and hence the desirability of greater care in the writing of descriptions.

V. A species of *Fusarium* has been found producing a serious leaf spot disease of carnations at Syracuse. It occurred upon plants so situated that the direct sunlight could not reach them. The fungus gains entrance through breaks in the epidermis made by rust sori. It is not improbable that it may be identical with the carnation stem-rot *Fusarium.*

VI. *Chaetomium contortum* Pk., a rare fungus hitherto found only on lily bulbs on Long Island, has occurred at Geneva under circumstances which aroused the suspicion that it is parasitic on barley seedlings; but an inoculation experiment showed that it is not parastic.

I. A BACTERIAL ROT OF ONIONS.[1]

In the autumn of 1898 the report came to the Experiment Station that the onions in Orange Co., N. Y., were rotting badly. Upon investigation it was found that in nearly all of the fields in this great onion growing district there was a considerable amount of rot. In many cases from one-third to one-half of the crop had to be rejected on account of it, and the remainder was not readily salable because news of the rot had reached New York city pro-

[1] This paper was read at the Columbus meeting of the Society for the Promotion of Agricultural Science, August 22, 1899, and will subsequently be published in the Proceedings of that Society.

duce dealers who were accordingly suspicious of all onions coming from Orange Co. The same rot was also common in the onion fields of Madison Co., but the losses from it there were not nearly so great as in Orange Co.

The rot was of two kinds: (1) One which starts at the bottom of the onion, and (2) One which starts at the top or "neck." The latter kind of rot was much the more common, constituting perhaps eighty per ct. of the total amount of rot. Where the rot had started at the top the bulbs were frequently sound in appearance, but rotten within. Oftentimes it was difficult to determine, before cutting, whether or not a bulb was rotten. In sorting, the customary test for soundness was to press down with the thumbs close about the "neck" of the onion. If it was hard the bulb was sound, but if soft it was usually rotten inside. Onion growers speak of such onions as being "weak in the neck." Upon cutting open the affected bulbs it was generally found that two or three of the outer scales were perfectly sound while the remainder of the bulb was a rotten mass. Frequently a single scale would be entirely rotten from top to bottom and clear around the bulb, while the remaining scales upon both sides of it, were perfectly sound. Such specimens cut crosswise showed the rotten part in the form of a ring. (See Plate X.) Again, a perfectly sound scale would be found between two rotten ones. (See Plate XI.) The rot appears never to spread from one scale to another laterally, and this peculiarity furnishes the most reliable means for the identification of this rot. The organism causing it is unable to pass through the uninjured epidermis of the scale. The passage from one fleshy layer to another is effected at the base of the bulb where they unite. Upon reaching the base of the scale in which it is working the rot commonly stops, and this accounts for the large number of cases in which one or two scales are rotten while the remainder of the bulb continues sound. Under certain conditions the rot does not stop at the base, but works its way into the bases of other scales which it then follows upward destroying the whole bulb.

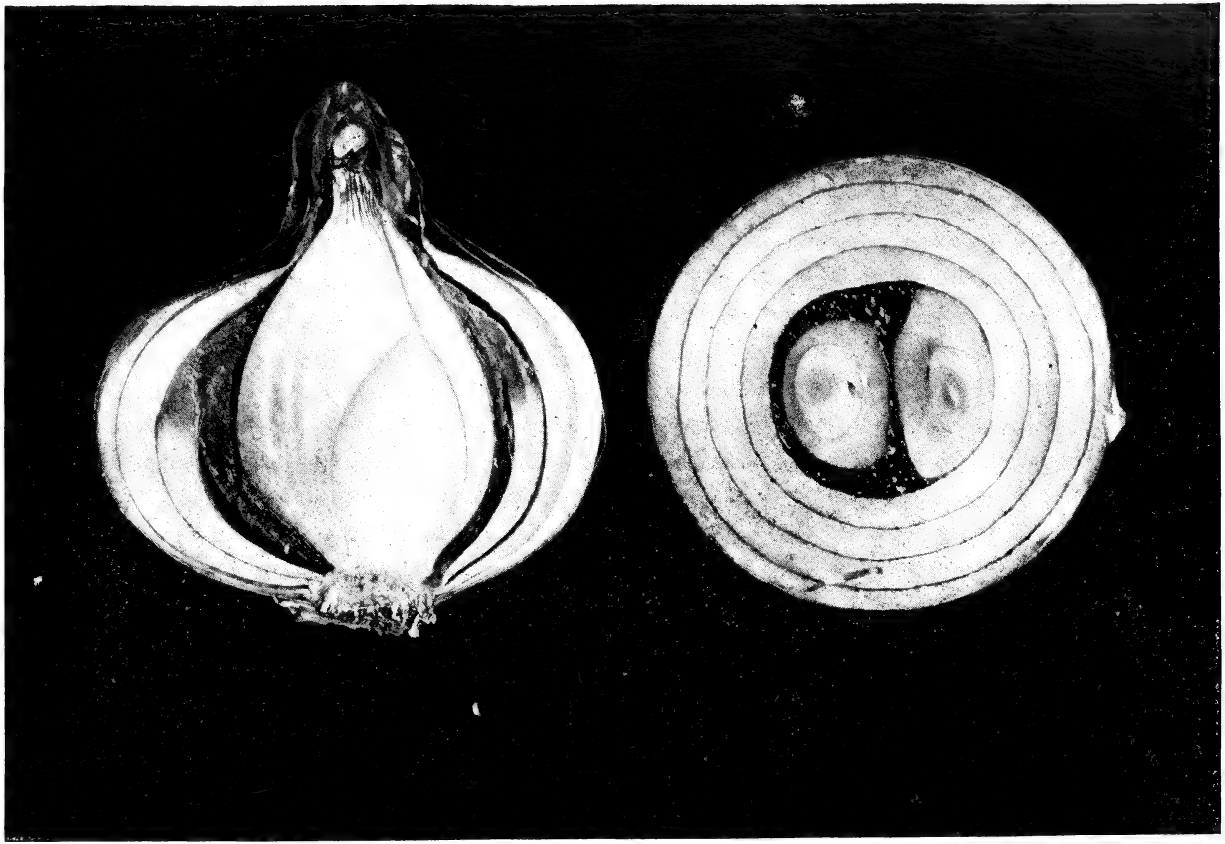

Plate X.—Onions Affected with Bacterial Rot.

When the rot is confined to the outermost fleshy scale, as is frequently the case, the affected bulbs are called "slippery onions." Some of these are to be found in any season, but they are rarely so abundant as to cause material loss.

Microscopic examination of the rotten tissue shows entire absence of fungi, but there are swarms of a medium-sized motile bacillus which is without doubt the immediate cause of the rot.

When the rot commences at the bottom of the bulb the whole lower part is soft and eventually the entire onion becomes involved. The rot spreads upward through all of the scales simultaneously. Bulbs so affected show a profuse growth of *Fusarium* about the base and the rotten tissue is filled with the *Fusarium* hyphæ mingled with the previously mentioned bacillus. Although the presence of the bacillus is sufficient to account for this base rot it seems probable that the *Fusarium* aids materially and in some cases it may be the primary cause.

By inquiry among onion growers it was learned that there is in nearly every season a small amount of loss from rot which usually appears in the form of "slippery onions," although both the center rot and the base rot have long have been known. The noteworthy fact in connection with the rot in 1898 is the unusually large amount of center rot.

The rot was noticed by farmers when the crop was harvested in August, but the full extent of the trouble was not realized until a month later when the crop was sorted for market. At first it was attributed to injury from hail which fell on July 30; but later the hail theory was rendered untenable by the discovery that there was considerable rot in fields which had not been struck by the hail. Probably, the wind accompanying the hailstorm was a much more important factor in the rot. In nearly all of the onion fields the tops were much broken by the wind.

Among stored onions kept reasonably dry the rot progresses very slowly, but wet onions rot rapidly, especially if the temperature is high.

All of the evidence obtainable goes to show that this bacterial rot is not new, but that it is an old enemy which found unusually favorable conditions for its development in some peculiarity of the weather during the season of 1898. As yet, no attempt has been made to determine the identity of the organism causing it. It may be the same as the one causing the rot of onions and other plants observed by Halsted[2] in New Jersey.

The weather records published by the New York State Weather Bureau show that the rainfall in Orange Co. was excessive and the temperature high from the middle of July to the close of August, 1898. At Middletown, which is on the edge of the onion district, the dates upon which rain fell[3] during this period were as follows:

RAINFALL AT MIDDLETOWN, N. Y., JULY 18 TO AUGUST 26, 1898.

Date.	Inches.	Date.	Inches.
July 18	.31	August 11	.80
July 19	.51	August 12	.08
July 20	.90	August 16	.28
July 21	1.85	August 17	1.31
July 26	1.04	August 19	.41
July 28	.09	August 23	3.08
July 30	1.09	August 24	.42
August 1	1.48	August 26	.52
August 4	1.15		
Total			15.42

In forty days 15.42 inches of rain fell and it was so evenly distributed over the period that the ground was almost constantly wet. The onion fields, being on a low level, were frequently inundated. In some cases whole fields were covered by the water for a period of from 12 to 36 hours. It is not strange that the onions rotted.

The important role which water plays in this rot is shown by the behavior of laboratory cultures. Sound onions were cut open,

[2] Halsted, B. D. The Root Rot of Salsify. Gard. and Forest. 3: 576. N. 1890: Also, Eleventh Ann. Rept. N. J. State Ag. Exp. Sta., 1890: 352.

[3] Rept. N. Y. State Weather Bureau, vol. X, No. 7, p. 11, and No. 8, p. 11.

placed in a moist chamber and inoculated upon the cut surface with bits of rotten onion. At the end of a week there was only a trace of rot at the points of inoculation. Similar inoculations with pure cultures of the *Fusarium* likewise gave negative results. Sound onions, in moist chamber, were bored to the center with an awl and bits of rotten onion introduced into the wounds. At the end of a week there were no signs of rot. This experiment was repeated several times and always with the same result — the onions refused to rot. During these experiments the temperature of the room varied from 21° to 26° C. (70° to 79° Fahr.).

Finally, sound onions inoculated externally with bits of rotten tissue were immersed in sterilized water and placed in an incubator kept at a temperature of 36° C. (97° Fahr.). Other sound onions were treated in the same way, except that they were not inoculated. Still others were inoculated by boring to the center and introducing rotten tissue. These latter were then put into the incubator with the others, but not immersed in water. At the end of six days all of the onions immersed in water were rotten, including checks; while those which had been inoculated, but kept dry, were still perfectly sound.

These experiments indicate that one important point in the prevention of this rot is to keep the onions dry. In practice this is to be accomplished by protecting stored onions from rain and by draining the fields so that water will not stand upon them for any length of time.[4]

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4 Since the above was written, some observations have been made upon the crop of 1899. The season of 1899 was unusually dry in Orange county, and yet there were a good many "slippery" onions in some fields. In looking over the onion fields, it was observed that some were almost entirely free from weeds, while others were thickly overgrown with them. It was in the latter kind of fields that the "slippery" onions occurred. The explanation of this appears to be that the weeds kept the onions wet by retaining the dew and some light showers which fell just before harvest time, thereby furnishing favorable conditions for the rot. Clean cultivation will have a tendency to reduce the amount of rot.

II. POWDERY MILDEW ON FIELD-GROWN CUCUMBERS.

In July, 1891, Humphrey[5] announced the occurrence of a powdery mildew on cucumbers in America. In his annual report[6] for that year he gave an extended account of the disease and stated that it had been found on hot house cucumbers at Fitchburg, Mass., and Ithaca, N. Y. His next annual report[7] contained drawings of the fungus and a brief recapitulation of the matter contained in the previous report. In Cornell Experiment Station Bulletin 31, page 31, Bailey has given a brief account of some experiments on the treatment of cucumber powdery mildew in the greenhouse.

So far as known to the writer, the above mentioned articles constitute the whole of the literature of powdery mildew on cucumbers in America. In the Ninth Massachusetts Report[8] Humphrey states that in America it is not known to him to attack cucumbers grown in the open air. It is therefore worthy of mention that in September, 1899, we received from F. L. Estabrook, of Athens, Pa., several leaves of field grown cucumbers which were thickly covered with a powdery mildew. Mr. Estabrook states that the mildew made its appearance some time in August and by September 22 was to be found upon every vine in the field and upon all parts of each vine excepting the younger leaves. In almost every case the older leaves near the root were the most severely attacked while the newer leaves toward the tip of the vine were generally free from it. The fungus was conspicuous and occurred chiefly upon the upper surface of the leaves but occasional spots of it were to be found upon the under surface. The fruits were exceedingly bitter and many were misshapen, but

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[5] Humphrey, J. E. The Powdery Mildew of the Cucumber. Mass. State Agr. Exp. Sta. Bul. 40: 3.

[6] Ninth Ann. Rept. Mass. State Agr. Exp. Sta., 1891: 222–226.

[7] Tenth Ann. Rept. Mass. Agr. Exp. Sta., 1892: 225–226.

[8] l. c., p. 222.

PLATE XII.—DODDER ON CUCUMBERS.

this may not have been wholly due to the powdery mildew. The plans were affected to a considerable extent also by downy mildew, *Plasmopara cubensis* (B. & C.) Humph.

Since no perithecia were found the identity of the fungus is a matter of conjecture. On his mildewed greenhouse cucumbers Humphrey found the perithecia of *Erysiphe cichoracearum* D. C. According to Frank[9] *Sphaerotheca castagnei* Lev. occurs on cucumbers in Europe, but the most common powdery mildew of cucumbers and other cucurbits in Europe is known only in the conidial form which passes under the name of *Oidium erysiphoides* Fr. Sturgis[10] assumes that the powdery mildew of the cucumber is identical with the one occurring on squash, but to us this appears extremely doubtful for the following reasons: The powdery mildew is common in this country on squash but on cucumber it is rare. During the past two seasons it has been abundant on both squashes and pumpkins in the vicinity of Geneva, but in no case have we observed it upon cucumbers, although cucumber vines have frequently been seen growing among mildewed squashes and pumpkins. *Vice versa,* on Mr. Estabrook's farm at Athens, Pa., a squash vine running among the mildewed cucumbers was entirely free from mildew.

Cucumber growers need not be alarmed at the appearance of this new parasite. It is not likely to become epidemic and in case it should do so it will probably not be found difficult to control.

III. DODDER ON CUCUMBERS UNDER GLASS.

The numerous species of dodder, *Cuscuta,* may be expected to occur on a great variety of plants in the open air, but it is unusual for them to attack greenhouse plants. An interesting case of dodder occurred in the Station cucumber-house last spring. In May, the writer observed a slender, yellow dodder thread twining about

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9 Frank, A. B. Die Krankheiten der Pflanzen. 2: 260. Eduard Trewendt, Breslau, 1896.

10 Sturgis, W. C. Twenty-First Ann. Rept. Conn. Agr. Exp. Sta., 1897: 214.

a cucumber plant. For a time it was permitted to grow unmolested in order to see what it would do; but it thrived so well and became so aggressive that the man in charge of the greenhouse found it necessary to take precautions to prevent it from spreading to the other plants. Four times during the spring the yellow threads were carefully removed. In spite of this rough treatment it flourished and fruited profusely and succeeded in thoroughly establishing itself upon four of the neighboring plants. The original host plant was greatly enfeebled by it, but not killed.

This dodder, which we have determined as *Cuscuta gronovii* Willd., may become troublesome unless dealt with vigorously. We advise the immediate destruction of affected plants.

IV. IS THE BALDWIN FRUIT SPOT CAUSED BY FUNGI OR BACTERIA?

There is a widely distributed and well known disease of the apple in which spots of brown, spongy tissue appear underneath the skin of the ripe fruit. On the surface of the fruit these spots are generally indicated by brown, more or less circular depressions having a diameter of from one-sixteenth to one-fourth of an inch. By different authors it has been given different names; *e. g.,* spot, brown spot,[11] dry rot,[12] bitter pit,[13] stippen,[14] etc.

This disease is of uncertain origin. Wortmann[15] thinks it due primarily to insufficient water in the affected parts. Most investigators have failed to find fungus hyphæ in the diseased tissue, but Jones[16] has attributed it to a fungus which Ellis determined as *Dothidea pomigena* Schw. Lamson[17] reports experiments in

11 Lamson, H. H. N. H. Agr. Exp. Sta. Bul. 65: 106. Illus.

12 Craig, John. Canada Exp. Farms Rept. for 1896: 171–172. Illus.

13 Cobb, N. A. Agr. Gaz. N. S. Wales, 9 (1898): 683. Illus.

14 Wortman, Jul. Ueber die sogenannten "Stippen" der Aepfel. Landw. Jahrb., 21 (1892): 663–675.

15 Loc. cit.

16 Jones, L. R. A Spot Disease of the Baldwin Apple. Fifth Ann. Rept. Vt. Agr. Exp. Sta., 1891: 133–134.

17 N. H. Agr. Exp. Sta. Bul., 45: 46–47: Bul. 65: 106.

which the amount of the disease was considerably reduced by spraying with Bordeaux mixture. This, also, indicates a parasitic origin. On the other hand Craig[18] says that spraying does not seem to prevent it, and this coincides with our own limited observations.

The descriptions given by the several authors whose work is mentioned above agree quite closely, and yet it is highly probable that they have been dealing with two or more distinct diseases. We have here an illustration of the desirability of more complete descriptions of the gross characters of plant diseases.

During the past season the writer has made an investigation into the cause of one of these fruit-spot diseases of the apple. It is a disease of the Baldwin and is generally known throughout New York State as the "Baldwin spot" or "Baldwin fruit spot." Although it undoubtedly originated somewhat earlier, it was not observed until the fruit was gathered, about October 7. The owner of the orchard estimated that a trifle less than two per ct. of the fruits were affected; however, on individual trees the percentage was much higher than this. The orchard had been thoroughly sprayed four times — twice before and twice after blossoming. It was well cultivated and is in all respects one of the best managed orchards in the vicinity of Geneva.

On the surface of the fruit the spots were very conspicuous. They varied in color from light brown to dark brown. Their general shape was circular, but very few were perfect circles. Sometimes they were quite irregular, but always with the corners well rounded and sharply delimited from the healthy tissue. The spots were slightly sunken, with the epidermis smooth, shiny and unbroken. In size they varied from a mere speck to one-fourth inch in diameter, the majority having a diameter of about one-eighth of an inch. The smallest spots might show no brown color at all, but be indicated merely by a deeper red color of the skin if situated upon the colored part of the fruit, or by a green

[18] Loc. cit.

color if situated upon the lighter portion. The number of spots on individual fruits varied from two or three up to as many as seventy-five, distributed irregularly over the calyx half of the fruit. It is an interesting fact, and one which may throw some light on the cause of the trouble, that the stem half of the fruit is almost invariably free from spots even when they are numerous on the calyx half.

Underneath the surface spots the tissue is light brown, dry and spongy for a distance of one-eighth to three-sixteenths of an inch. This spongy tissue is not bitter to the taste[19] or at least but slightly so. At the time the fruits were gathered the spongy tissue was found only underneath the surface spots, but after they had lain some three weeks in the laboratory many brown spots were found distributed irregularly through the flesh of the calyx half of the fruit, but not in the stem half. These spots were irregular in shape, indefinite in outline and in many cases entirely surrounded by healthy tissue.

Several other varieties of apples of this State are affected with spots similar to those on the Baldwin, but the following study was confined to the Baldwin spot here described, and the conclusions apply to this one form only.

Microscopic examination of the affected tissue revealed no fungus hyphæ and no bacteria which could be definitely demonstrated as such. Commencing October 7, two of the affected Baldwins were kept for 21 days in a moist chamber at a temperature of 65° to 74° Fahr. During this time the spots did not enlarge (externally, at least), no fungus appeared upon them and they did not increase in number upon the surface although they did increase in number *within* the fruit.[20] When these apples

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19 This is a point on which the spot disease under consideration differs from the descriptions of Jones and Cobb.

20 The reason for believing that the spots increased in number within the fruit, is as follows: When the apples were taken from the trees, many of them were cut open, and in no case were the spots found, except immediately under the epidermis; but after affected apples from the same lot had been off the trees for about three weeks, they universally showed brown spots scattered through the flesh quite to the core.

finally rotted the rot started on the stem half instead of the spot-affected calyx half. At another time, two affected apples were kept in a moist chamber for 18 days with the same results.

Next, an experiment was made to determine if the diseased tissue would produce any growth when placed in culture media. Four Petri dishes[21] containing potato agar slightly acidified with lactic acid were each inoculated at three different points with small pieces of the brown spongy tissue. This gave twelve points of inoculation with material from twelve different spots. The cultures were kept at the room temperature, about 70° Fahr. At the end of eight days one point of inoculation was overrun by a fungus which had gained admission to the culture by accident. The other eleven points of inoculation were entirely free from growth of any kind.

On November 1 six tubes of neutral beef-peptone agar were inoculated with small pieces of the brown, spongy tissue taken from six different spots, and then poured into Petri dishes. At the end of eight days the only growth in the six dishes consisted of one fungus and two yeast colonies which were evidently intruders. We now tried cultures in an atmosphere devoid of oxygen. Six tubes were used — two of potato agar, two of beef-peptone agar and two of beef-peptone agar containing two per ct. of lactose. One tube of each kind was slightly acidified with malic acid and the other left neutral. The six tubes were inoculated with bits of spongy tissue from six different spots, thoroughly shaken and placed in a large bottle from which the oxygen was then removed by means of pyrogallic acid and potassium hydroxide solution. These cultures were kept at a temperature of about 80° Fahr. for one week but they produced no growth whatever.

Finally, at the suggestion of Mr. H. A. Harding, Station Bacteriologist, we tried apple peptone agar[22] as a culture medium.

21 Two dishes acidified at the rate of one drop of 50 per cent. lactic acid to 10 c. c. agar, and the other two dishes at double this rate.

22 Baldwin apple, 400 germs. Witte's peptonum siccum, 10 germs. Agar, 15 germs. Water, 1 liter.

Three tubes of this medium carefully neutralized with sodium hydroxide, and three tubes unneutralized were inoculated with the spongy tissue and kept 24 days in air at a temperature of about 80° Fahr. Six other tubes of the same medium, three neutralized and three unneutralized, were inoculated and kept for the same length of time at a temperature of about 80° Fahr. in an atmosphere devoid of oxygen. No growth appeared in any of the twelve tubes.

From the result of this study we conclude that the form of apple fruit-spot described above is not caused by fungi or bacteria, but what the real cause may be we are not prepared to state.

Wortmann[23] observed that starch is present, often in considerable quantity, in the brown, spongy tissue, while the surrounding healthy tissue is almost, if not wholly, destitute of starch. We find that the spongy spots lying just beneath the epidermis generally contain considerable starch, but the deeper-lying spots (which, as has been stated, are formed after the fruit is gathered) rarely contain more than traces. This difference in starch content is brought out very strikingly when a section of apple showing both kinds of spots is smeared with a solution of iodine and potassium iodide. The sub-epidermal spots become black, showing the presence of starch, while the interior spots are not altered in color.

When an apple is bruised without breaking the epidermis the tissue becomes brown and spongy and resembles somewhat the brown, spongy spots under discussion. We have found this bruised tissue loaded with starch, while the surrounding uninjured tissue contained no starch. Green apples contain starch which is changed into sugar as the fruit ripens. It, therefore, seems probable that the bruises which responded to the test for starch were made before the fruit was ripe. Upon the death of the cells their activities ceased and the transformation of starch into sugar was arrested. This theory accounts for the absence of starch from late formed spots.

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23 Loc. cit., p. 663.

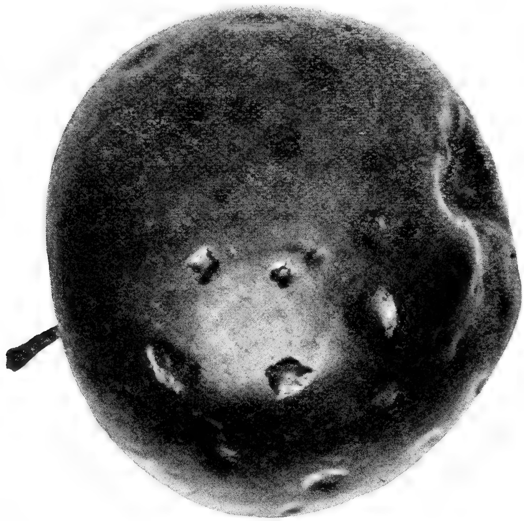

FIG. 1.—BALDWIN APPLE AFFECTED WITH FRUIT SPOT.

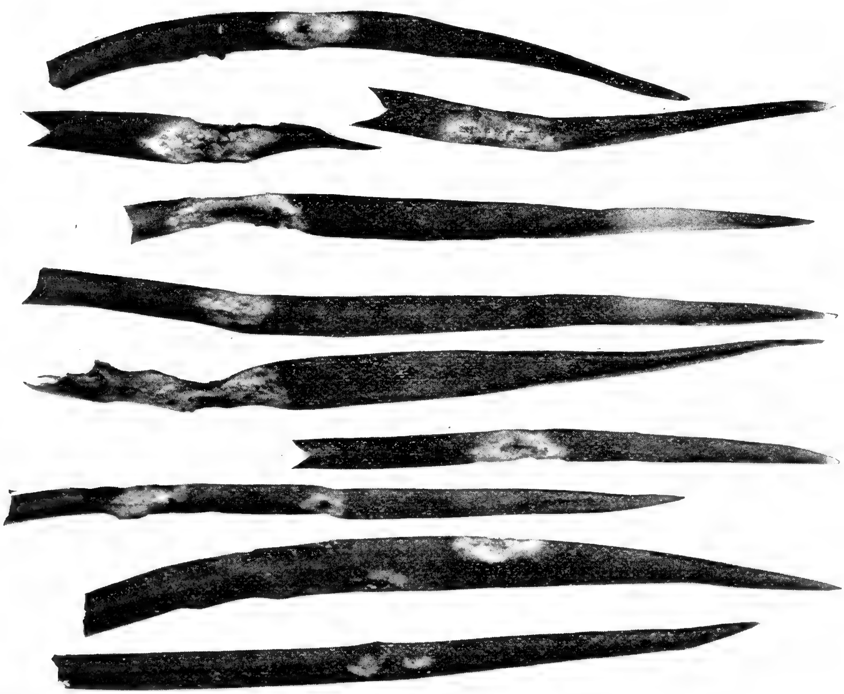

FIG. 2.—CARNATION LEAVES AFFECTED WITH *Fusarium* LEAF-SPOT.

PLATE XIII.

An experiment was made to determine if bruises made after the fruit was ripe would cause the appearance of starch in the bruised tissue. On December 6, apples of the variety Pride of Texas were bruised without breaking the epidermis, and then kept at a temperature of 60°F. At the end of three weeks the bruised tissue contained a little starch, but the quantity was very small as compared with that found in old bruises on the same variety.

V. A FUSARIUM LEAF-SPOT OF CARNATIONS.

A very unusual case of *Fusarium* attacking carnation foliage was observed in a greenhouse at Syracuse last November. A bench of carnations of the variety Emily Pierson was quite seriously affected with a peculiar leaf-spot. The spots varied in length from one-eighth of an inch to one inch. The smaller ones were elliptical, but the larger ones occupied the entire width of the leaf and were irregular at the ends. They were covered with a pinkish gray mold and irregularly dotted at the center with the light yellow spore masses of a species of *Fusarium*. Many of the worst affected leaves were dying. The *Fusarium* was evidently parasitic on the leaves, but a careful examination revealed the fact that in every case the spots originated in a rust[24] sorus. It appeared that the *Fusarium* was unable to attack the uninjured leaf, but when the epidermis was broken by rust it was able to enter and bring about decay of the leaf tissue. It is improbable that the *Fusarium* is parasitic upon the rust.[25]

The writer has occasionally observed *Fusarium* attacking injured leaves and stems of carnations and the spore masses of a similar *Fusarium* are common on the stems of carnations affected

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24 *Uromyces caryophyllinus* (Schrank) Schroet.

25 In this connection it may be mentioned that Mr. F. H. Blodgett, Assistant Botanist and Entomologist, observed at Mattituck, N. Y., last August, a *Fusarium* growing abundantly on the uredo sori of *Puccinia asparagi*, D. C. However, in this case, the *Fusarium* was not confined so strictly to the rust sori, but occurred also upon the so-called leopard spots and sometimes even upon the uninjured asparagus stems.

with that form of stem-rot commonly known as dry rot or die back;[26] but we have never before known *Fusarium* to produce a genuine leaf-spot of carnations. Inoculation experiments may show that this *Fusarium* is identical with the one causing carnation stem-rot.

The plants were grown under conditions exceptionally favorable to the attack of fungi. They were so situated that direct sunlight never reached them. However, they were doing fairly well and were free from disease with the exception of the *Fusarium* leaf-spot and a moderate attack of rust.

VI. *CHAETOMIUM CONTORTUM* ON BARLEY SEEDLINGS.

In March, 1895, the writer found a new species of *Chaetomium* on some lily bulbs in a greenhouse on Long Island. The fungus was sent to Dr. C. H. Peck, State Botanist, who named it *Chaetomium contortum*.[27] For nearly four years after this nothing was heard of it; then it was again found in one of the Station greenhouses. In December, 1898, some barley seedlings used in an experiment on plant nutrition began to languish without apparent cause. Upon making an examination of the diseased plants it was found that several perithecia of *Chaetomium contortum* were seated on the seed pericarps which still remained attached to the young plants. So far as known none of the species of *Chaetomium* are parasitic, but this case was so suspicious that it was decided to test the matter by experiment. Fifty seeds of barley were planted in each of two boxes in sterilized soil. One of the boxes was inoculated at three points with pure cultures of the *Chaetomium*

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26 For an account of the *Fusarium* stem-rot of carnations, see: Sturgis, Wm. C. Preliminary Investigations on a Disease of Carnations. Twenty-First Ann. Rept. Conn. Agr. Exp. Sta., 1897: 175–181. Also, Stewart, F. C. The Stem-Rot Diseases of the Carnation. Bot. Gaz., 27: 129–130.

27 Forty-Ninth Ann. Rept. N. Y. State Museum. Report of State Botanist, p. 24.

and the other used as a check. When they had reached a height of six to eight inches the plants were all in perfect health. Nevertheless, upon pulling them up it was found that a majority in both boxes had perithecia of *Chaetomium contortum* on their pericarps. This proved that the *Chaetomium* was not parastic. The spores must have become attached to the barley seeds before they were planted.

A FRUIT-DISEASE SURVEY OF THE HUDSON VALLEY IN 1899.*

F. C. Stewart and F. H. Blodgett.

SUMMARY.

This bulletin contains an account of the fruit diseases occurring in the Hudson Valley in 1899. The various diseases are considered individually with reference chiefly to their distribution and the amount of damage done; but descriptions and additional notes have been given wherever it has been thought that they would be of interest either to the fruit-grower or the vegetable pathologist.

The data have been obtained by two methods: (1) From replies to letters of inquiry sent to fruit-growers, and (2) From personal observations made by the authors.

The season has been an unusually dry one and as a consequence fruit of all kinds has been remarkably free from disease. Some of the diseases usually very common and destructive have, this season, done little or no damage.

Apples have suffered from no disease — not even from scab. Rust has been the worst disease of blackberries. It has a tendency to reduce the number of prickles. Cherries have suffered most from fruit-rot which has been severe in a few localities. In the Hudson Valley black knot is common on the cultivated cherries but does not occur on the wild black cherry. Cane blight has been the worst disease of currants. In the Hudson Valley it is not

* Reprint of Bulletin No. 167.

caused by *Nectria* but by a sterile fungus. It is wide spread and destructive. The four-lined leaf-bug causes a currant leaf-spot which is confused with that due to fungi. An obscure dewberry disease was observed. Gooseberry powdery mildew has been troublesome in Ulster and Columbia counties. A gooseberry root rot has been found at Marlboro. Grape black rot has done serious damage in a few instances. Grape root rot due to *Dematophora* and grape black knot occurred in Orange Co. Winter injury to fruit-buds caused heavy losses to peach growers. Peach leaf curl has been conspicuous by its absence, but the yellows is common. Pears have suffered from no disease. In former years black knot ruined the plum orchards, but it has probably not spread much in 1899. Plum fruit-rot has been destructive. Quinces have been affected considerably with fruit-spot and leaf-blight. The worst disease affecting the raspberry this season is an obscure one which may be caused by *Phoma*. Raspberry anthracnose was rare on new canes, but abundant on fruiting canes. Strawberry leaf-blight has been severe on some varieties. None of the above diseases were so destructive as in 1898.

INTRODUCTION.

Since its organization, in 1897, the Eastern New York Horticultural Society has had a standing committee on plant diseases. The membership of this committee is a follows: F. C. Stewart, Geneva; F. A. Taber, Poughkeepsie; E. W. Barns, Middle Hope; P. W. King, Athens; and L. E. Covert, Clintondale.

The two published reports[1] of the Committee are brief for two reasons; namely, lack of data and lack of space for publication. During the past season the committee has endeavored to do more thorough work. A considerable amount of data has been gathered, and to present it in as much detail as seems desirable would

[1] Fifty-Seventh Ann. Rept. of the N. Y. Agr. Soc., 1897: 735–738.

make a longer paper than the Society would be willing to publish in its Proceedings. Moreover, much of the matter is of more than local interest, making it desirable to publish it where it will have a wider circulation than has the Proceedings of the Society. Hence the publication of this bulletin.

THE SURVEY: METHODS AND GENERAL RESULTS.

TERRITORY COVERED BY THE SURVEY.

The territory covered by the survey includes only the counties bordering upon the Hudson River between Albany and New York City; namely, Albany, Rensselaer, Greene, Columbia, Ulster, Dutchess, Putnam, Orange, Rockland, and Westchester counties. In order that the region investigated might be as nearly as possible a natural plant region, and yet cover the greater part of the territory included in the membership of the Society, Long Island and Staten Island were excluded. The usual climatic conditions prevailing there are markedly different from those which obtain in the Hudson Valley. The district under consideration is about 160 miles in length and 45 to 50 miles in width with the Hudson River running through the middle. (See Plate XIV.)

WEATHER CONDITIONS.

It is well known that weather conditions, especially rainfall and temperature, exert a powerful influence upon the growth of fungi. Fungous diseases of plants are much more destructive in wet seasons than in dry ones. In the Hudson Valley, the spring and summer of 1899 were unusually dry and the temperature somewhat higher than normal, offering a marked contrast to the season of 1898, which was very wet. The monthly precipitation for the season of 1899 is shown in the accompanying table:

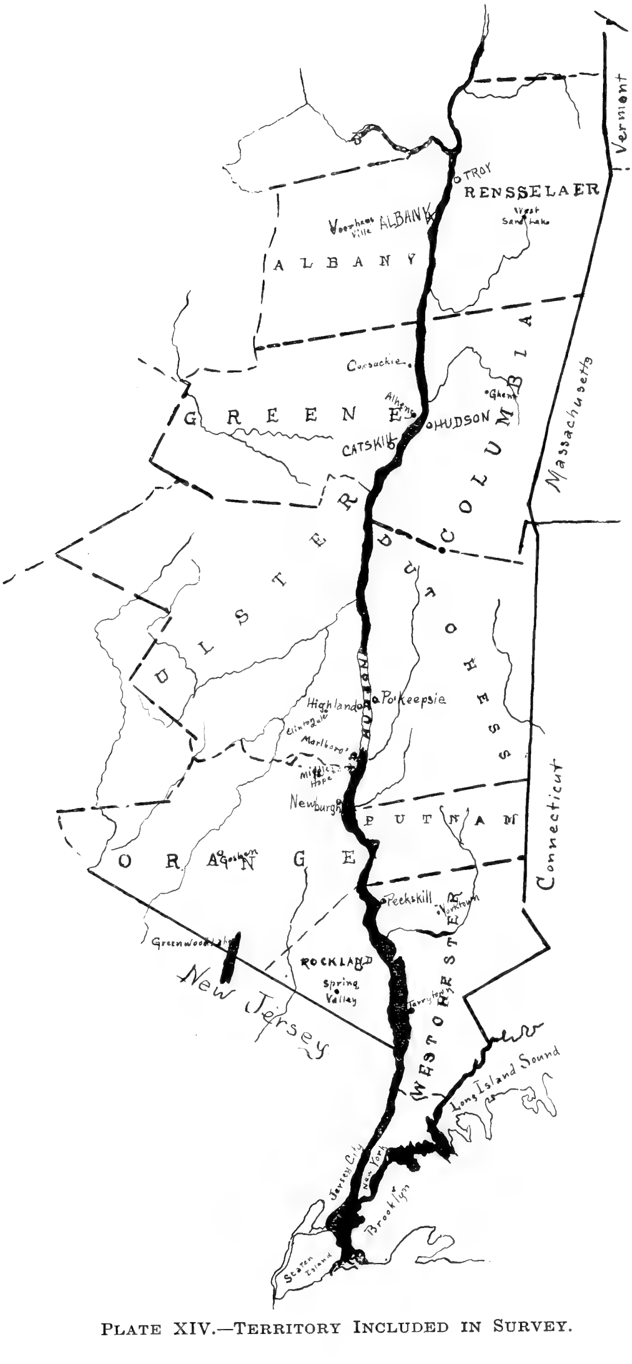

PLATE XIV.—TERRITORY INCLUDED IN SURVEY.

PRECIPITATION IN THE HUDSON VALLEY.— APRIL TO SEPTEMBER, 1899.[2]

Station.	April.	May.	June	July.	Aug.	Sept	Total for six mos.
	In.	In.	In.	In.	In.	In.	In.
Albany	1.03	2.23	1.61	2.69	1.77	6.23	15.56
Catskill	2.26	2.12	1.24	3.59	2.21	6.49	17.91
Poughkeepsie	0.20	1.27	1.74	5.56	1.68[3]	4.99	15.44
West Point	1.70	2.31	4.85	5.78	1.90	6.39	22.93
Bedford	2.11	2.36	4.73	6.65	0.89	5.03	21.57

METHODS OF OBTAINING DATA.

It is a favorite method with plant disease committees to send out circulars of inquiry to fruit growers asking for information concerning fruit diseases which have appeared during the season. We have done this and gotten considerable valuable information; but this method is applicable only to a few of the most common and best known diseases. In the first place the majority of fruit growers will pay no attention to such a circular. Out of a total of 250 circular letters enclosing self addressed envelopes for the reply we have had returned to us only 59. Secondly, the replies are often misleading. They are usually based not upon careful observations properly recorded, but upon loose general impressions. Furthermore, the laity are able to identify accurately only a very few diseases. Frequently, two or more distinct diseases pass under one common name. Blight, leaf-spot, rust, fruit-rot and root-rot are examples of this. What is commonly called pear leaf-spot is caused by two quite different fungi, but there are very few persons not experts who know the difference between them. We have in New York, three fungous diseases and an insect trouble which are covered by the one common name, currant leaf-spot. Even so well known a disease as peach leaf curl is sometimes confused with the distortions caused by plant lice.

[2] The records for April, May, and June, are taken from the U. S. Monthly Weather Review; those for July, August, and September, from the N. Y. Climate and Crop Service monthly reports.

[3] The August record for Poughkeepsie is lacking; the figures here given are for Wappinger's Falls, the nearest record station.

Appreciating the limitations and inaccuracies of the circular-letter method, the committee planned to supplement the data obtained in that way with data obtained from observations made by experts. For this purpose the Chairman associated with himself Mr. F. H. Blodgett, Assistant Botanist and Entomologist, who made three two-day and three three-day trips to different localities in the southern half of the district for the purpose of inspecting fruit plantations, taking notes on fruit diseases and collecting specimens. The Chairman made six similar trips of inspection to localities in the northern half of the district.

This combination of circular-letter method and expert inspection is a good one. The two methods supplement each other admirably.

The following is a copy of the circular letter sent to fruit growers, the spaces for answers being omitted:

CIRCULAR LETTER OF INQUIRY SENT TO FRUIT GROWERS.

GENEVA, N. Y., *Nov.* 15, 1899.

DEAR SIR.— The undersigned, a Committee on Plant Diseases, appointed by the Eastern New York Horticultural Society, wish to get together information in regard to the most troublesome diseases prevalent the past season among orchards, vineyards and nurseries in the Hudson River Valley. They issue the following circular in the hope that prompt replies may enable them to prepare a valuable report for the next meeting of the Society. Will you kindly fill out the blanks below and return at once? Please answer only those questions concerning which you can give positive information. Address your reply to the chairman, F. C. Stewart, Geneva, N. Y.

1. Which of the following plant diseases have caused serious injury in your locality during the past season–

ORCHARD DISEASES.

Apple.
- Pear blight (Fire blight).
- Scab.
- Leaf spot.

Pear.
- Leaf blight.
- Pear blight (Fire blight).
- Scab.

Quince.
- Fruit spot and leaf blight.
- Pear blight (Fire blight).

Plum.
- Black knot.
- Fruit rot.
- Leaf blight.

Peach.
- Fruit rot.
- Leaf curl.
- Yellows.
- Little peach.

Cherry.
- Fruit rot.
- Leaf blight.

NURSERY DISEASES.

Apple.
Powdery mildew.

Pear.
Leaf blight.
Pear blight (Fire blight).

Cherry.
Leaf blight.
Powdery mildew.

Plum.
Leaf blight.

Quince.
Leaf blight.

Peach.
Root knot.
Powdery mildew.

VINEYARD DISEASES.

Black rot.
Downy mildew (brown rot or gray rot).

Powdery mildew.
Anthracnose.
Rattling or shelling.

SMALL FRUITS.

Raspberry.
Anthracnose.

Strawberry.
Leaf blight.

Currant.
Leaf blight.
Cane blight.

Gooseberry.
Mildew.

2. Of the diseases mentioned, please name the worst three.

3. In each of the above cases, give, if possible, the percentage of the crop injured, stating the basis upon which you make your estimate.

4. What remedies, if any, have been used for plant diseases in your locality?

5. With what success have these been used?

6. Have any new or unusual diseases appeared; if so, give description, amount of damage done, and any other items concerning them.

F. C. STEWART,
F. A. TABER,
E. W. BARNES,
P. W. KING,
L. E. COVERT,
Committee.

MAGNITUDE OF THE FRUIT INDUSTRY.

Fruit growing is one of the leading industries throughout the whole district. In several localities it is practiced to the exclusion of all other branches of agriculture. The most prominent of these special fruit growing localities is in the southeastern part of Ulster County around Marlboro, Milton and Highland.

The fruits grown extensively are apples, cherries, currants, grapes, peaches, pears, raspberries and strawberries. There are several commercial plantations of gooseberries, blackberries and

quinces. Plums are grown to a considerable extent, but not so much as formerly. Apricots and dewberries are rare.

There are but few nurseries in the district.

GENERAL STATEMENT OF RESULTS.

Fruits generally have been remarkably free from diseases of all sorts.[4] Nearly all fruit growers with whom we have talked upon the subject say that all fruits have been freer from disease the past season than for many years. There has not been an epidemic of any disease and some of the common destructive diseases have been almost entirely absent. Fruit diseases have been conspicuous by their scarcity. Consequently, quite as much is said in this bulletin about what has *not* been found as what *has* been found.

It is to be regretted that a thorough survey of fruit diseases in the Hudson Valley was not made in 1898. The season of 1898 was very wet and fruit diseases generally were unusually destructive. A comparison of the two seasons would be instructive.

The replies to questions two and six of the circular letter were so few and so unsatisfactory that they have not been considered. The replies to questions four and five indicate that Bordeaux mixture, although used to a considerable extent, is not in as general use as it should be.

APPLE DISEASES.

In quantity, the apple crop of 1899 was, perhaps, no more than an average one; but the fruit was remarkably fair, being unusually free from blemishes of all sorts. Nevertheless, apples have not kept well. This is due partly to the warm autumn[5] and partly to the fact that the fruit ripened prematurely. Certain winter varieties, for example Baldwins and Greenings, have in some cases behaved more like late fall varieties.

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4 This statement does not apply to insect injuries.

5 It is believed by some that the very heavy frost on October 3 (25° at Honeymead Brook, 27° at Wappinger's Falls), seriously injured the keeping qualities of apples.

SCAB.

(*Venturia inaequalis* (Cke.) Adeh. Syn. *Fusicladium dendriticum* (Wallr.) Fckl.)

This arch enemy of the apple has done very little damage. It has been reported as occurring to a slight extent in all the counties in the district except Albany, Ulster and Putnam, but only one correspondent (Old Chatham, Columbia Co.) reports it troublesome. On June 20 we sought in vain for a single specimen of scab in an 80-acre apple orchard at Poughkeepsie. In 1898 this orchard suffered severely from scab. At Washingtonville scab spots were common on the twigs of the Lady apple, which is a variety very susceptible to this form of attack.

LEAF SPOT.

(*Phyllosticta* spp.)

What a correspondent thought to be leaf spot occurred injuriously at Schodack Landing, Rensselaer Co. In some orchards 25 per ct. of the foliage was affected. Upon investigation it was found that the so called leaf spot was the work of an insect,[6] the resplendent shield-bearer (*Aspidisca splendoriferella*).

The true fungus leaf spot has been much less common than scab, but traces of it have occurred at various points in the district. No attempt was made to distinguish between the two species.

TWIG BLIGHT.

(*Bacillus amylovorus* (Burr.) DeToni.)

Rare. A few affected twigs were observed in Albany Co.; and three correspondents, one each in Orange, Ulster and Rensselaer counties, report its occurrence in small quantity.

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[6] On the authority of Mr. F. A. Sirrine, who examined some of the affected leaves.

CANKER.[7]

(*Sphaeropsis malorum* Pk.)

This disease has killed a good many Spitzenberg trees in the vicinity of Voorheesville and New Scotland in Albany Co. It occurs destructively at Pomona and Blauvelt in Rockland Co. At Blauvelt it is especially troublesome on the variety Sour Bough. It has also been observed at Yorktown and Poughkeepsie.

SOOTY BLOTCH.

(*Phyllachora pomigena* (Schw.) Sacc.)

Rare. A little found on apples received from Newburgh and Yorktown.

RUSSETING OF FRUIT.

Russeted apples are reported to have been common in the vicinity of Hudson. We have seen the disease on Baldwins and Ben Davis at Poughkeepsie. The affected fruits were frequently misshapen and showed irregular areas on which the skin was rough and light brown in color. This appearance is sometimes due to spraying and sometimes to weather conditions alone.[8] It is often incorrectly called rust.

RUST.

(*Gymnosporangium* spp. Syn. *Roestelia* spp.)

This is a fungous disease in which circular yellow spots appear on the leaves in June. It may attack the fruit also. The red cedar, the host of the teleuto stage of the fungus, grows spontaneously throughout the entire district and "cedar apples" were found quite commonly upon it during early May in Ulster and Rockland counties; but the æcidial stage upon the apple has been entirely absent.

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[7] For an account of Apple Canker, see Bulletin 163 of this station.

[8] See Bulletin 84 of this station, pp. 29–33.

SUN-CRACK.

On June 2 some apple-tree trunks were observed at Ghent on which the bark was loose and dead over areas from two to four inches in width and from one to four feet in length. These injuries were on the southwest side of the trunks and usually, but not always, extended quite to the ground. It first appeared in the spring of the present year. The trees were unusually thrifty, about seven years old and of the variety Willow Twig. They stood in well drained soil. We are of the opinion that it was caused by the sun's rays heating the bark intensely in early spring while the soil about the roots was still deeply frozen. That is to say, this is a case of what Hartig[9] calls sun-crack (*Sonnenriss*).

A sun-crack or perhaps sun-scald of apple tree trunks locally known as "southwest blight" is of common occurrence in the vicinity of Washingtonville.

BROWN, SUNKEN SPOTS ON THE FRUIT.[10]

A disease of this description has been reported as occurring on Greenings and Baldwins at Clintondale.

APRICOT DISEASES.

Apricots are not cultivated to any extent within the district. The only disease with which we met was one occurring at Ghent. Some trees which have been planted for several years have been dying off mysteriously one at a time for a few years past. A tree may die either in part or wholly at any time during the growing season. Some died in the spring of 1899. Just above the surface of the ground the bark is dead, often for considerable distance up the trunk; but the wood is not laid bare. Sometimes the bark shrinks

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9 Hartig, R. Text-Book of the Diseases of Trees (p. 296). Translated and revised by Somerville and Ward. The Macmillan Co.: New York, 1894. Dr. Hartig informs us that Fig. 159, which purports to illustrate sun-crack, is misnamed. The injury was caused by lightning.

10 A description of this disease and an account of an investigation into its causes are given in Bulletin 164 of this station.

tightly to the wood. Between the bark and the wood there may be much fungus mycelium, probably the mycelium of *Irpex lacteus* Fr. since pilei of that fungus were found on one of the dying trunks. One of the diseased trees was dug up for the purpose of examining the roots, which were seemingly healthy and free from fungus. There was no sharp line of demarcation between the diseased and healthy wood at the point where the scion joined the stock.[11] The trees were thrifty, having been well cultivated and cared for. The cause of this disease is unknown to us. It occurs in other parts of the state, sometimes causing heavy losses.

BLACKBERRY DISEASES.

ORANGE RUST.

(*Puccinia peckiana* Howe. Syn. *Caeoma nitens* Schw.)

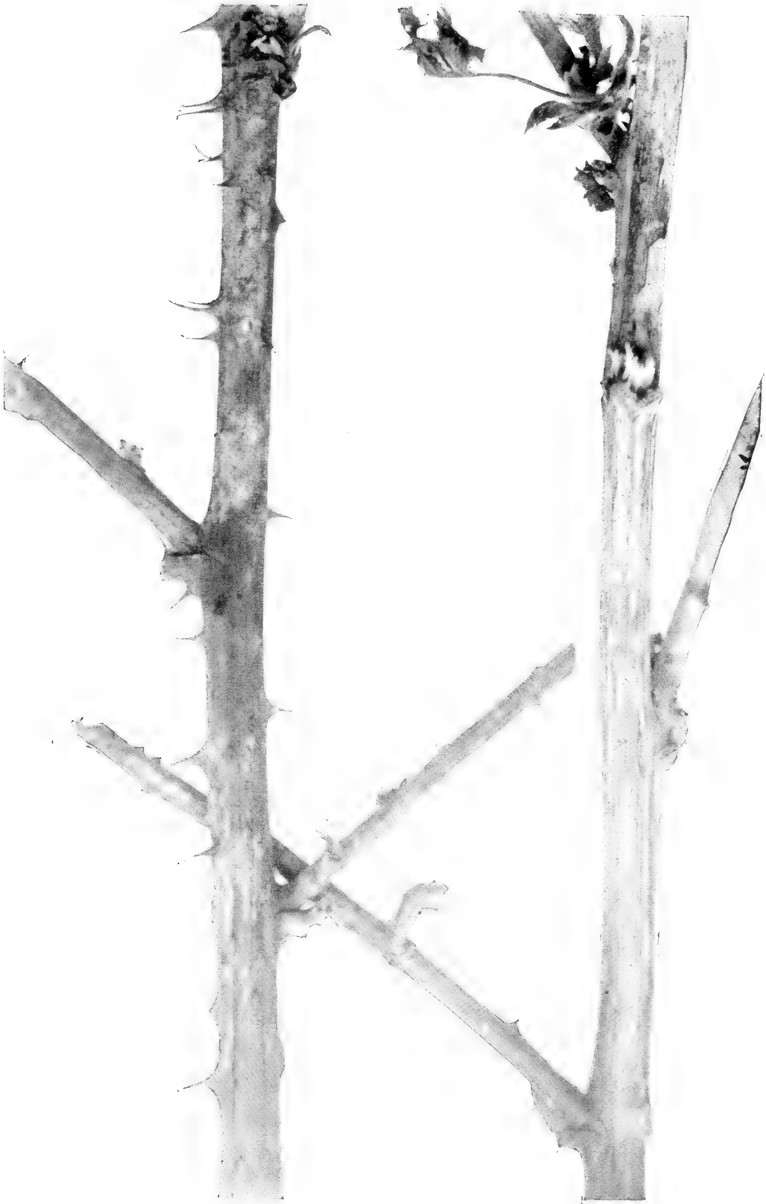
Orange rust, although less distructive than usual, was abundant and undoubtedly the worst blackberry disease. For several years W. D. Barns & Son of Middle Hope have persistently fought the disease by digging out and burning the affected plants. It is probable that this treatment has materially lessened the ravages of the disease, but in spite of their efforts it continues to cause considerable damage every season. To get the best results from such treatment the diseased plants should be removed promptly upon the first appearance of the disease to prevent the spores from ripening.

At Mr. Barns' place our attention was called to an interesting effect which rust has upon the canes of raspberries and blackberries. *Canes affected with rust were much freer from prickles*[12] than were healthy canes.

These observations were made on May 8, at which time the rusty canes of the preceding season's growth were easily recognized although the æcidiospores were not yet mature. Among black-

[11] The stock was peach.

[12] No reference to this phenomenon has been found in the literature at hand. Mr. W. Paddock informs us that he has observed it at Oaks Corners, Ontario county.



HEALTHY. RUSTED.

PLATE XV.—A HEALTHY AND A RUSTED BLACKBERRY CANE FROM THE SAME HILL.

berries of the variety Wilson Jr., the rust-affected canes were almost or even wholly destitute of prickles. It is not an uncommon thing to find healthy canes and rusted canes of blackberry in the same hill.[13] Such cases offered an opportunity for close comparison and it was found that the difference in the number of prickles on the two sorts of canes in the same hill was very marked. (See Plate XV.) The difference is so great that Mr. E. W. Barns says he can pick out the diseased canes in winter by their freedom from prickles. On affected raspberry canes the reduction of prickles was very evident but not so marked as with the blackberry.

After these observations at Middle Hope, we examined, during the season, many rusty blackberries, raspberries and wild dewberries (*Rubus canadensis* L.) in various localities. With all of these plants we found that rust in some cases caused a great reduction of prickles; in other cases, partial reduction; and in still others, no reduction at all. At Yorktown badly rusted blackberries of the variety Minnewaska were observed which showed no apparent reduction of prickles.

LEAF SPOT.

(*Septoria rubi* Westd.)

Rare. Observed only at Poughkeepsie.

CHERRY DISEASES.

FRUIT ROT.

(*Monilia fructigena* P.)

As usual, fruit rot has been the worst cherry disease, but was not nearly so destructive as in 1898. From Westchester Co. it is reported "bad on some varieties." In Rockland Co. it destroyed

13 This has also been observed by Clinton; Orange Rust of Raspberry and Blackberry. Ill. Agr. Exp. Sta. Bul. 29: 276. D. 1893. It occurs less commonly with the raspberry, probably on account of the more compact habit of growth at the crown.

about 25 per ct. of the latest sweet cherries. Orange Co. correspondents report but little damage from it. At Kinderhook, Columbia Co., it was "unusually developed." In the vicinity of Delmar, Albany Co., it is reported to have destroyed about 10 per ct. of the crop; and in one orchard about 50 per ct. A correspondent at Highland, Ulster Co., reports the loss of one-half his crop; but from personal observations we would say that, in general, cherries suffered but little from rot in that locality.

LEAF SPOT.

(*Cylindrosporium padi* Karst.)

This disease has occurred in small amount over the whole district, but no case has been reported in which it has done serious damage.

BLACK KNOT.

(*Plowrightia morbosa* Sacc.)

Throughout the Hudson Valley black knot is common on cultivated cherries of some varieties. English Morello probably suffers most. Trees of this variety are frequently ruined by it. At Middle Hope, Orange Co., Montmorency and Early Richmond cherries are said to knot considerably. At Coxsackie, Greene Co., we found knots on English Morello cherries producing summer spores as early as June 1. Black knot is exceedingly common on plums over the whole district. In former years it has been a veritable scourge. With these facts before us it is an interesting observation that, although the wild black cherry, *Prunus serotina* Ehrh., is very common and we have searched carefully, *not a single specimen of black knot has been found upon it.*[14]

The wild red cherry, *Prunus pennslyvanica* L. f., is common in Albany Co., but we have failed to find any affected by black

[14] Peck, also, has noted the absence of black knot from *Prunus serotina* in Eastern New York. See Forty-Second Ann. Rept. N. Y. State Mus. Nat. Hist., 1888: 125. On Long Island, black knot is abundant on this species.

knot. In the central part of Rensselaer Co. we have examined the choke cherry, *Prunus virginiana* L., which grows wild there, but found no knots upon it. However, at Washingtonville, Orange Co., the latter species is said to be much affected.

What has been said applies only to old knots. The observations furnish no information as to the number of knots produced by infections occurring in 1899, for the new knots do not appear until late in autumn, after the time when the survey was finished.

WITCHES' BROOMS.

(*Exoascus cerasi* (Fckl.) Sadeb.)

Knowing that this disease is not uncommon in some other parts of the State[15] we expected to find it in the Hudson Valley, but failed to find a single specimen.

POWDERY MILDEW.

(*Podosphaera oxyacanthae* (D. C.) De By.)

On July 20, a single bearing cherry tree affected with powdery mildew was observed at Delmar, Albany Co. A few leaves at the ends of the twigs were affected.

FUNGUS ON DEAD TRUNKS.

(*Irpex lacteus* Fr.)

On a fruit farm at Middle Hope we observed many dead cherry trees bearing numerous pilei of *Irpex lacteus* Fr.[16] The trunks were from three to five inches in diameter and in many cases were thickly covered with the fungus to a height of from three to five feet. The owner explained that the trees were of the variety Elkhorn, which is not hardy. Most of the trees had died during the past three or four years, apparently from winter injury.

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15 See Fourteenth Ann. Rept. of this station, 1895: 532–533; also, Fifteenth Rept., 1896: 459. In May, 1899, we found a single large specimen on an ox-heart cherry (*Prunus avium*), at Sodus Center, in Wayne county, about five miles from the shore of Lake Ontario.

16 Identified by Dr. C. H. Peck.

The fungus probably had nothing to do with the death of the trees. It is mentioned here because it is a conspicuous thing which might be mistaken for a parasite.

WINTER INJURY.

At Athens, Greene Co., three cherry trees 15 years old died mysteriously. They had been very thrifty, but last spring when the leaves were partly grown the trees suddenly died. They grew in a slight depression where water stands in wet seasons. It is likely that the trees went into the unusually severe winter of 1898–9 with "wet feet" and were winter killed. This theory is supported by the fact that another tree of the same age and variety standing only about 16 feet away but outside of the depression was not affected. Some pear trees standing within the depression and close beside the dead cherry trees were not killed.

Another case of what we consider to be winter injury occurred at Monsey in Rockland Co. Some cherry trees which had been planted in the spring of 1898 and made a vigorous growth that season were found badly injured in the spring of 1899. A few of the trees were killed outright, but with a majority of them only the branches were killed back for a distance of from 12 to 24 inches from the tips. The affected portions did not put out leaves. Trees standing in exposed situations suffered most. The owner thought that the injury might have been caused by bands of tarred paper which had been placed about the bases of the trunks to protect them from mice; but this theory is made untenable by the observation that the bark under the tarred paper bands was perfectly healthy.

Some other cases of the unaccountable dying of branches in cherry trees may also be due to winter injury.

A BRANCH PARASITE.

(*Polyporus sulphureus* (Bull.) Fr.)

On a cherry tree in Greene Co., five pilei of this fungus were found on the uninjured bark of a large limb which was rapidly dying. The fungus was apparently parasitic.

CURRANT DISEASES.

LEAF SPOT.

The fungi which cause leaf spot of currants in the Hudson Valley are *Septoria ribis* Desm., *Cercospora angulata* Wint., and *Gloeosporium ribis* (Lib.) Mont. & Desm. During the season of 1899 none of these did any damage worth mentioning. Only traces of fungous leaf spot were found in a few localities. Experiments by Pammel,[17] Goff,[18] and others have shown that at least the first two and most common of these fungous leaf spot diseases can be controlled by spraying with Bordeaux mixture. However, at various times complaints have been received that spraying does not prevent currant leaf spot.

The observations in the Hudson Valley throw some light on the cause of these failures. One of the best informed fruit growers in Columbia County called our attention to a bad case of currant leaf spot which he had tried in vain to prevent by spraying with Bordeaux mixture. Several thousand currant cuttings had been sprayed with Bordeaux during the first week in May and again about two weeks later. In spite of this treatment the plants were severely attacked during the last week in May by a disease which the owner did not doubt was the fungous leaf spot said to be amenable to treatment. An examination of the affected plants revealed the fact that the trouble was entirely the work of the four-lined leaf-bug,[19] *Poecilocapsus lineatus.* The leaves were thickly covered with small, reddish-brown, angular spots. In the early stage the spots were black and water soaked in appearance, but they soon became brown, dry and transparent. (See Plate XVI, fig. 1.) The epidermis, on both sides of the leaf, was depressed, but no gnawing of the tissue was evident. The insect thrusts its beak into the leaf and sucks out the juices.

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17 Pammel, L. H. Iowa Agr. Exp. Sta. Bul. 13: 45–46; Bul. 17: 419–421; Bul. 20: 716–718; Bul. 30: 289–291.

18 Goff, E. S. Wis. Agr. Exp. Sta. Bul. 72: 30.

19 For an account of the habits, life history, etc., of this insect, see Cornell Agr. Exp. Sta. Bul. 58. O. 1893.

Later, the work of the same insect was found sparingly at Kinderhook, Highland and Clintondale and very abundantly at Tarrytown; but in all these cases on bearing bushes.

It seems probable that the injuries of the four-lined leaf-bug are often mistaken for fungous leaf spot. Currant growers should learn to distinguish between these two kinds of leaf spot. The insects, being small and very active, are not much in evidence. The spots which they produce differ from fungous spots in being transparent. They attack chiefly the leaves near the tips of the canes.

CANE BLIGHT.

The most destructive disease of currants in the Hudson Valley the past season was a cane blight. The leaves on one or more canes in a hill suddenly wilt and soon thereafter the canes die and become dry. The disease may be confined to a single short branch or it may affect several large canes. The entire hill may eventually succumb, but this rarely happens during the first season of attack. It commenced early in May and continued throughout the whole season, being most active while the fruit was ripening.

We first became acquainted with this cane blight in June, 1896, when specimens of it were sent to us from Marlboro. From these specimens it appeared that the trouble was due to a sterile fungus working in the pith and under the bark. Through the kindness of Mr. S. A. Beach it was learned that Mr. D. G. Fairchild had made a brief study of the same disease in 1891 and had given a talk upon it before the Botanical Club of the American Association for the Advancement of Science at its meeting in Washington in August, 1891. He attributed it to a sterile fungus. A short account of this talk was published in the *Botanical Gazette* for September, 1891, page 262.

Before having an opportunity to study the disease in the field we learned that Dr. E. J. Durand, of Cornell University, was

investigating a currant cane blight having the same symptoms, in Western New York. Upon the appearance of his bulletin[20] in which it was stated that *Nectria cinnabarina* Tode was the cause of the disease, we concluded that the sterile fungus observed by Fairchild and by us was probably only a saprophyte; but our observations during the past season have convinced us that it is really an active parasite. The disease occurs to a greater or less extent throughout the entire Hudson Valley. In many plantations it is very destructive. We have cut open and examined several hundred, perhaps as many as a thousand, of the affected canes, and almost invariably found the sterile fungus in the pith and under the bark. Its presence can generally be determined with the unaided eye and nearly always with the aid of a good hand lens. In a very few cases, perhaps half a dozen, we have found borers; but in no case have we found *Nectria cinnabarina* either in its perithecial or conidial stage. *The currant cane blight occurring in the Hudson Valley is not caused by* Nectria cinnabarina *but by a sterile fungus.*[21]

When a cane of the previous season's growth first shows wilting of the leaves it appears normal externally. But on splitting an affected stem there will usually be found a place near the base of the affected portion, where the bark is dead and the wood and pith dead and discolored for an inch or more. The presence of the fungus is manifested by delicate cobwebby patches of hyphæ in the pith. This is the seat of the trouble, and from it as a center the fungus spreads both ways; upward, so as to frequently occupy the whole wilted branch, and downward so as to kill successively the lower branches of the cane. The disease seems to strangle the canes near the point of infection, killing the portion beyond by cutting off the supply of sap.

In canes of the present season's growth the fungus spreads

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20 A Disease of Current Canes. Cornell Exp. Sta. Bul. 125. F. 1897.

21 Exact proof by inoculation experiments is lacking. But the large number of cases in which the sterile fungus has been found associated with the disease is considered sufficient proof for this statement.

upward so rapidly that the whole cane is discolored and permeated by the fungus hyphæ throughout its entire length soon after the leaves are wilted. In the pith of such specimens the hyphæ are especially conspicuous.

In the currant cane the hyphæ are white or dirty white, but on bean stem cultures they soon become smoke colored or even black. No spores or other indications of fructification have been observed and nothing is known of the manner in which the fungus is disseminated. It occurs upon both red and white currants, *Ribes rubrum,* and has also been observed in one case upon the black currant, *R. nigrum.*

The diseased canes should be cut out and burned. In doing this care should be taken to cut well below the lowest point of the disease; otherwise the labor is wasted. Also, the pruning knife should be frequently dipped into some disinfecting solution; for example, a 5 per ct. solution of carbolic acid. If this is not done pruning may serve to spread the disease instead of checking it.

It is hoped that a thorough study of this disease may be made in the near future.

DEWBERRY DISEASES.

There are probably other commercial plantations of dewberries in the Hudson Valley, but we have made observations upon one only, which was located at Highland in Ulster County. The plants were of the variety Lucretia. They were trained up to stakes, several canes to each stake. During the previous winter they had been allowed to lie upon the ground. In the spring they put out leaves normally, but later a good many of them died. Some were just commencing to wilt at the time of our observations (June 21). It was rare to find all of the canes in a hill dead. Usually, from one to four of the canes were dead and the rest apparently healthy. As a rule the affected canes were green and healthy for a few inches above the soil; then there came a blackened (but not constricted) portion a few inches long, which seemed to be the seat of the trouble. No fungus was

visible upon any of the dead parts and no fungus hyphæ were found in the bark or pith. It is not likely that this was winter injury or the effect of drought. We cannot account for it.

A small amount of leaf spot (*Septoria rubi* Westd.) occurred in this plantation.

GOOSEBERRY DISEASES.

POWDERY MILDEW.[22]

(*Sphaerotheca mors-uvae* (Schw.) B. & C.)

This is the most destructive gooseberry disease. It is reported to have been very bad in Ulster and Columbia counties. One correspondent reports that his Downing gooseberries sprayed four times with Bordeaux mixture were almost free from mildew, while with the variety Industry, given the same treatment, one-half of the crop was ruined. The disease occurred also in Dutchess county.

ROOT ROT.

During the past five years a destructive root rot disease has existed in a gooseberry plantation at Marlboro. It started at one corner of the plantation and gradually spread, killing every plant as far as the disease extended. At the present time the affected area measures about 40 by 50 feet. The plants die gradually, living from one to four years after the appearance of the first symptoms of disease. Dead canes and living ones occur in the same hill, but the leaves on the living canes are more or less dwarfed. Early in May we had the privilege of examining about a dozen of the affected plants which had recently been dug up. Upon the roots of all of them there was a conspicuous white mycelium. It was at once concluded that this fungus was the cause of the trouble, and from the nature of the rhizomorphs referred it provisionally to the form-genus *Dematophora*.

In November the Horticulturist had occasion to remove a lot of seedling gooseberries which had been growing between the rows

22 For experiments on the treatment of this disease, see Bulletin 161 of this Station.

in one of the Station vineyards for six seasons. Although but few of these plants had been grown thriftily, none of them had shown pronounced symptoms of disease. Accordingly, we were surprised to find the roots of many of them covered with the same fungus which had been found on the diseased gooseberries at Marlboro. The fact that it occurred on apparently healthy plants caused us to doubt the correctness of our former conclusions.

Pieces of the fungus-infested roots were stuck in moist sterilized sand in a Mason fruit jar previously made sterile by a solution of corrosive sublimate. In about six weeks they began to show conidial fructification like that of *Dematophora*.

From diseased grape roots placed in the Mason jar sand cultures we had previously obtained the conidial fructification of a *Dematophora*. (See Grape Root Rot.) The rhizomorphs of the gooseberry fungus were strikingly like those of the grape *Dematophora* except that the hyphæ composing them were slightly smaller. Accordingly, we expected to get the same sort of conidial fructification; but the spores of the gooseberry fungus were larger and the branching of the sporophores different. We believe the gooseberry fungus to be a species of *Dematophora*, but there is some doubt about it being an active parasite.

During the past season the gooseberry disease at Marlboro spread but little owing probably to the dry season. In the wet season of 1898 it made rapid progress. The owner of the diseased gooseberries believes that the plants have died through some evil influence of a large black walnut tree[23] which stands at the corner of the plantation where the disease started; but it is scarcely possible that this can have been the direct cause.

DWARFED FOLIAGE.

In another gooseberry plantation we saw a few plants which appeared healthy, except that all of the leaves were abnormally

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23 For another case of supposed injury by black walnut tree, see Grape Root Rot on pages 297–298.

small. The owner states that in 1898 there had been many plants so affected. The affected plants were intermingled with healthy ones.

GRAPE DISEASES.

BLACK ROT.

(*Laestadia bidwellii* (Ell.) Viala & Ravaz.)

Black rot has been, as usual, the worst grape disease, but was not nearly so destructive as in 1898. The worst case we have seen or heard of this year occurred at West Nyack, Rockland County, where 75 per ct. of the crop was ruined by it. In some vineyards in Westchester County, it is reported to have caused a loss of 50 per ct. From various other localities it is reported destructive in unsprayed vineyards.

Bordeaux mixture, properly applied, is an almost certain preventive of this disease. It should be more generally used in the Hudson Valley.

DOWNY MILDEW.

(*Plasmopara viticola* (B. & C.) Berl. & De Toni.)

This disease appears to have been scarce except in the southern part of the district where it was destructive in a few vineyards. At West Nyack it was severe on several varieties, but showed a decided preference for the variety Delaware.

ROOT ROT.

(*Dematophora necatrix* (?) Hartig.)

While on a visit to Middle Hope we were informed that in a vineyard near that place grape vines had been killed by a black walnut tree. We visited the vineyard and found that the tree, which was of enormous size, stood about 40 feet from the edge of the vineyard. Opposite the tree all of the vines over a small semi-circular area had died. The owner stated that peach trees had been planted in the vacant area but they, too, had died. We dug up some of the dead vines and found the roots covered

with a white mycelium. Pieces of the fungus covered roots were stuck into wet sand in a sterilized Mason fruit jar. In this culture the white mycelium was gradually replaced by numerous light brown rhizomorphs and after three months the roots became thickly covered with the conidial fructification of *Dematophora.* The sporophores measured from one to one and one-half millimeters in height. To the unaided eye they appeared to be short, brown stalks with colorless or purple ovoid knobs on their ends. Under the microscope the brown stalks proved to be compound sporophores, composed of brown, septate hyphæ; and the colorless, ovoid knobs were composed of small, colorless, ovoid spores borne on the branched free ends of these hyphæ. The fungus agreed closely with Hartig's description[24] of *Dematophora necatrix* except that the hyphæ composing the rhizomorphs were destitue of pyriform swellings at the septa.

The *Dematophora,* and not the walnut tree, was probably the cause of the death of the vines. Some of the dead vines were certainly beyond the reach of the roots and shade of the tree. The soil was a sandy loam and well drained. See Gooseberry Root Rot, page 203.

CHLOROSIS OR YELLOW FOLIAGE.

In an old but well cared for vineyard at Coxsackie we found many plants showing yellow foliage by June 1. The yellow leaves were much dwarfed. Sometimes the whole vine was affected, but it often happened that a part of a vine would be diseased and a part healthy. According to the owner, affected canes die the following winter. When all of the canes are affected and die, new canes come up from the root. The affected plants were scattered irregularly over the vineyard.

Chlorosis may be due to several causes. Not having had oppor-

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24 Hartig, R. *Dematophora necatrix,* n. sp. Untersuchungen aus d. forstbotan. Institut zu München. III, 1883.

tunity to study this case thoroughly no statement is made as to its cause.

BLACK KNOT.

A considerable number of specimens of this disease were found in an old vineyard at Middle Hope. At a distance of from six inches to two feet above the ground the stems showed warty excrescences of spongy texture. (See Plate XVII.) No knots were found on the roots or at the crown. These excrescences bear a striking resemblance to the black knots on plums and cherries caused by the fungus *Plowrightia morbosa* (Schw.) Sacc., but they have an entirely different origin. European investigators hold that they are due to the action of frost.[25]

The disease appears to be rare in the Hudson Valley, but in Central and Western New York it is met with frequently. It is also reported from Pennsylvania,[26] California[27] and Canada.[28] From American writers on plant diseases it has received very little attention, although it has a considerable literature in French, German and Italian.

PEACH DISEASES.

WINTER INJURY.

The Hudson Valley peach crop of 1899 was almost a complete failure owing to the hard freeze in February which killed nearly all of the fruit buds. There were very few orchards that bore any fruit. In many orchards the twigs also were much injured and in some the trees were killed outright. The severe attack of leaf curl in 1898 probably made the trees unusually susceptible to winter injury.

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25 See Frank, A. B. Die Krankheiten der Pflanzen, 1: 209–210. Breslau, 1895.

26 Galloway, B. T. Botanical Div. U. S. Dept. Agr. Bul. 8: 63.

27 Woodworth, C. W. Cal. Exp. Sta. Bul. 99: 2. This, however, may be a different disease.

28 Fletcher, Jas. Canada Experimental Farms Rept. for 1889: 87.

LEAF CURL.

(*Exoascus deformans* (Berk.) Fckl.)

Leaf curl has given very little trouble. Over the greater part of the district it is reported as occurring only to a slight extent. Correspondents at Stockport, Columbia Co., and Annandale, Ulster Co., report it severe; but it is possible that in these cases the fungous leaf curl may have been confused with the work of plant lice.[29]

It appears that the weather conditions in early spring exert a a marked influence upon leaf curl. In 1898 it was very destructive.

YELLOWS.

This disease is common throughout the Hudson Valley and in some localities very destructive. From year to year it fluctuates somewhat in virulence, but may be depended upon to appear to a considerable extent every season. It is one of the most troublesome peach diseases in this section.

FRUIT ROT.

(*Monilia fructigena* P.)

Usually this disease is common, but in 1899 it was scarce because there was little fruit to rot. It has been reported from Tarrytown, Milton, Ghent, Middle Hope and Washingtonville.

LEAF TIP-BURN.

In a small orchard of young trees at Monsey, Rockland Co., a leaf trouble was observed which may be called tip-burn. The tips and margins of the leaves on the new wood appeared water-soaked[30] and transparent. Upon drying, the diseased portions became yellowish white. The trees were of the variety Red Cheek

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29 Some fruit growers know the *Exoascus* disease by the name "red blister," and the work of aphides by the name "leaf curl." This tends to confusion.

30 The water-soaked condition may not be a character of the disease, but due to a rain which occurred a short time before the observations were made.

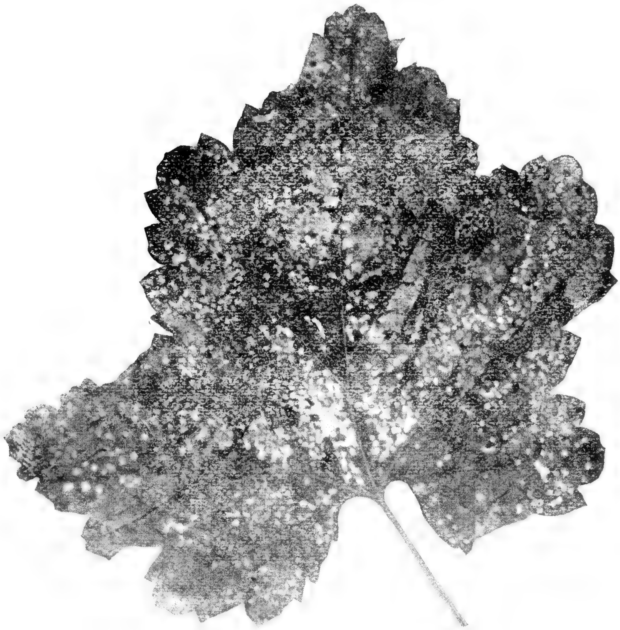

FIG. 1.—CURRANT LEAF INJURED BY FOUR-LINED LEAF BUG.

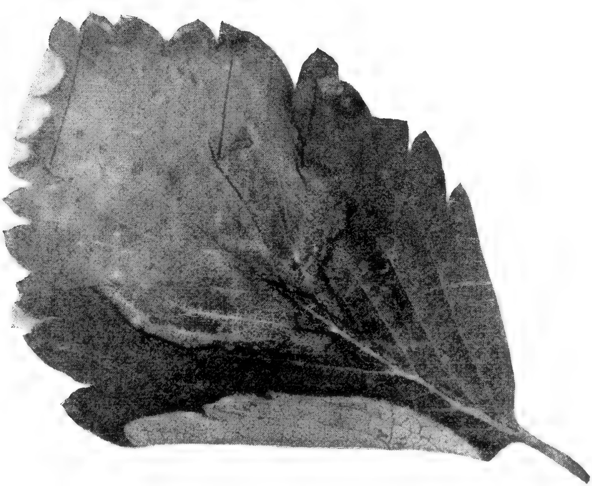

FIG. 2.—STRAWBERRY LEAFLET AFFECTED BY SUN-SCALD.

PLATE XVI.

and had suffered severely from leaf curl the previous season. The observations were made on May 24, at which time the tip-burned leaves were abundant. The cause of it is unknown to us, but it is probably not of fungous origin.

POWDERY MILDEW AND SCAB.

Neither powdery mildew nor scab, *Cladosporium carpophilum* Thum, is known to have occurred anywhere in the Hudson Valley during the past season.

PEAR DISEASES.

SCAB.

(*Venturia pirina* Aderh. Syn. *Fusicladium pirinum* (Lib.) Fckl.)

Pears have been remarkably free from scab. Many of our correspondents report none of it; several report "a little;" and a few report its occurrence in considerable quantity. Judging from these reports it appears to have been worst in Columbia Co., but in no case was it so bad as last season.

LEAF BLIGHT AND LEAF SPOT.

(*Entomosporium maculatum* Lev. and *Septoria piricola* Desm.)

Only eight correspondents report the occurrence of pear leaf blight, and none of these report it destructive. Not having succeeded in taking a single specimen ourselves we do not know which of the two diseases was the more common.

FIRE BLIGHT.

(*Bacillus amylovorus* (Burr.) De Toni.)

Although more common than either scab or leaf blight, the fire blight has been destructive in only a few localities.

"BODY BLIGHT" OR ROUGH BARK.

There is a disease of the trunks and larger branches of pear trees commonly known as "body blight." Over areas which are

at first small and more or less circular, but later coalesce into large patches of various shapes, the bark is dead and dry and clings tightly to the wood. By the shrinkage of the bark in drying the affected areas become slightly depressed and bounded by a crack which separates them sharply from the adjacent healthy bark. This gives the affected trunks and branches a rough, cracked, unhealthy appearance. The trees are seldom killed outright, but their growth is checked, often to such an extent as to hopelessly stunt them.

"Body blight" has generally been considered to be a form of the fire blight caused by the microorganism *Bacillus amylovorus;* but according to Paddock[31] it may be caused by the apple canker and black rot fungus, *Sphaeropsis malorum* Pk. It is not our purpose to discuss here the nature of the disease, but to report its common occurrence in the Hudson Valley. In all of the counties within the district excepting Rockland, Putnam and Westchester it was found in great abundance. In a severely attacked orchard in Greene County, portions of several trees appeared to have been killed by it. The branches were thickly covered with the pycnidia of *Sphaeropsis malorum.* A few trees after struggling along in a half dead condition for several years finally died, apparently from *Sphaeropsis.*

WINTER INJURY (?)

In each of several orchards in the vicinity of Athens, Greene County, a few pear trees died mysteriously. They seemed to have died from some cause which killed the bark just below the surface of the soil. The parts above ground appeared normal. To the unaided eye no fungus was present on the roots or on the dead bark of the subterranean portions of the trunk. There were no signs of insects. In all cases the dead trees stood in a heavy clay soil and were scattered irregularly through the orchard among healthy trees.

31 Paddock, Wendell. The New York Apple-Tree Canker. Bul. 163 of this station, p. 203.

PLUM DISEASES.

BLACK KNOT.

(*Plowrightia morbosa* (Schw.) Sacc.)

About 20 years ago plum growing was an important industry in the Hudson Valley, particularly in Greene Co. About 1884 there was an epidemic of black knot which ruined most of the plum orchards and so discouraged fruit growers that few have had the courage to replant on a large scale. Another, but less destructive epidemic occurred in 1891. At the present time the Japanese plums are being planted quite largely. They are not affected to an injurious extent by the black knot. On the European varieties it is still very troublesome and an epidemic may be expected whenever a favorable season occurs. It has probably spread but little during the past season.

FRUIT ROT.

(*Monilia fructigena* P.)

The Hudson Valley plum grower has another serious enemy in the brown rot of the fruit. In spite of the very dry season this disease has been quite bad in some localities. At Millbrook, Dutchess Co., it is reported to have destroyed two-thirds of the crop; at Old Chatham, Columbia Co., 50 per ct. of the crop; at Annandale, Ulster Co., Newburgh, Orange Co., and at Blauvelt, Rockland Co., 25 per ct. It was also abundant in Westchester Co., and occurred to a considerable extent in Greene and Rensselaer counties.

LEAF BLIGHT OR "SHOT HOLE" DISEASE.

This disease is commonly caused by the fungus *Cylindrosporium padi* Karst., but Duggar[32] has recently shown that it may be produced by Bordeaux mixture, especially if improperly prepared; by other chemicals and even by certain weather conditions.

32 Duggar, B. M. Peach Leaf-Curl and Notes on the Shot Hole Effect of Peaches and Plums. Cornell Agr. Exp. Sta. Bul. 164. F. 1899.

Leaf blight has been reported from a few localities, but does not appear to have been serious except in a few cases where it was evidently caused by spraying. At Yorktown, Japan plums were observed which were severely" shot holed " by spraying with carefully made dilute Bordeaux mixture.

A correspondent from Stockport, Columbia Co., writes: " The plums, both sprayed and unsprayed, looked well until after the first heavy rain, when, on the trees that had been sprayed, the leaves spotted, turned red and fell off. I think this must have been due to the spray, as the unsprayed trees were not affected." We think that this opinion is correct.

LEAF CURL.

(*Exoascus mirabilis* Atk.)

A few shoots of Wild Goose plum affected with this fungus were observed at Tallman, Rockland Co.

QUINCE DISEASES.

FRUIT SPOT AND LEAF BLIGHT.

(*Entomosporium maculatum* Lev.)

Fruit spot and leaf blight are caused by the same fungus. It is reported to have been abundant in Columbia, Westchester and Orange counties. A correspondent at Ghent dug out all of his bushes because of it. This was quite unnecessary because Bordeaux mixture would have prevented the disease at a very small cost.

FIRE BLIGHT.

(*Bacillus amylovorus* (Burr.) De Toni.)

The fire blight on quince is the same as that occurring on pear and apple. It was reported by three correspondents to have occurred in small quantity.

RASPBERRY DISEASES.

ANTHRACNOSE.

(*Gloeosporium venetum* Speg.)

The replies to our circular letter of inquiry indicate that raspberry anthracnose has been common. Although not so stated, these replies probably relate to anthracnose on last year's canes. Judging from our own observations we believe that canes of the present season's growth have been but slightly affected.

RUST.

(*Puccinia peckiana* Howe. Syn. *Caeoma nitens* Schw.)

Rust has occurred in several plantations, but not to a destructive extent except in a very few cases. Under some conditions rust has a tendency to reduce the number of prickles. For a more detailed discussion of this subject, see Blackberry Rust, page 194.

ROOT GALLS.

We know of but one occurrence of this disease in the Hudson Valley. Others probably exist, however. In April a fruit grower at Madalin, Dutchess County, sent us a red raspberry root bearing several rough, spongy, roundish knots or galls varying from the size of a pea to that of a walnut. The sender wrote that in the spring of 1898 he had purchased 30 Loudon raspberry plants from a Rochester nurseryman. A year later half of them had died from the root galls.

The cause of such root galls is not known. There is some evidence that the disease is communicable from one plant to another, and also from raspberries to peaches and *vice versa.* Plants showing root galls should not be planted, not even after the galls have been removed.

WINTER INJURY.

Red raspberries not laid down were injured by the severe winter. At Poughkeepsie, red raspberries of the variety Marlboro winter-killed nearly to the ground, while Miller's Red in the

same field and under parallel conditions suffered but slightly. In a plantation of red raspberries at Marlboro, canes which passed the winter tied up to stakes were killed back from six to eighteen inches. The injury was worse on low ground.

CANE BLIGHT.

(? *Phoma.*)

In various localities in the northern part of the district there is a common disease of raspberries, which may be called cane blight for want of a better name. On June 1 it was observed at Coxsackie on black raspberries. Its attacks were confined almost exclusively to old canes. The owner states that it rarely attacks young canes, but did so to some extent last season. Some canes were dead, others nearly dead, and still others showing the first symptoms. The affected canes showed a brownish black discoloration of the bark which was dead. Usually the discoloration extended the whole length of the cane on one side only, the bark on the other side remaining alive and green. Numerous pycnidia of at least four different species of fungi were found on the dead bark. The predominating form was a species of *Phoma* having small, round or slightly ellipsoidal spores with a brownish tinge.

At Poughkeepsie on June 20, we found what appeared to be the same disease killing the canes of black raspberries. It was destructive. Canes here and there were dying and their abundant fruit, which was nearly ripe, was drying up. The owner thought it the effect of drought. Here, as at Coxsackie, only the fruiting canes were affected. The affected plantation was an old one. An adjacent plantation of young plants of the same variety was not affected. The tendency of the canes to die on one side was not so pronounced as at Coxsackie, but pycnidia of the same *Phoma* were abundant and occurred so close to the healthy bark as to indicate that the fungus was parasitic.

On July 19 the same disease on black raspberries was found at Voorheesville. Here it had ruined one-third of the crop. It was

in a plantation five years old. The owner states that it occurs chiefly in old plantations, those two and three years old usually being exempt. It is worst on high ground and occurs in wet seasons as well as dry ones. The canes commenced to die about the time the fruit began to ripen. Often the entire cane was affected, but frequently only a part of it. Healthy and diseased branches occurred on the same cane. Sometimes a cane would be dead upon one side and in a semi-living condition upon the other. The pycnidia of the *Phoma* were to be found on almost every affected cane, and where one was killed back only part way the pycnidia would be clustered just above the boundary between the living and the dead tissue.

At Voorheesville the disease was noticed attacking also red raspberries of the variety Cuthbert. Berries, leaves and wood suddenly dried up while the fruit was ripening. Usually, but not always, the whole cane was affected. At some point on the cane there were numerous pycnidia of the same *Phoma* found on black raspberries. When only a portion of a cane was affected the pycnidia were commonly clustered (as on black raspberries) just above the boundary between the diseased and healthy bark. On the red raspberry the pycnidia appear to the unaided eye somewhat different from those on the black raspberry.

A disease having the same symptoms attacks the Marlboro, a red variety extensively planted in the Hudson Valley. On this variety it is especially destructive and is everywhere known as "the Marlboro raspberry disease." A bad case of this was observed at Delmar, but the examination was so hasty that little can be said concerning it. It is certain, however, that the *Phoma* was not so abundant as in the previously mentioned cases. At this place the yellow variety, Golden Queen, was also attacked by it.

At West Sand Lake it was destructive on the variety Shaffer, being worse in the older portions of the plantation. Correspondents report it from various other localities. It is a widespread and destructive disease.

It seems probable that the disease of red raspberries is the same of that of the black varieties. It may, perhaps, be aggravated by drought, but the evidence in hand is opposed to the theory that drought is the sole, or even the principal, cause. In the first place the symptoms are not those of drought. On raspberry canes suffering from drought the foliage becomes yellowish, the berries are abnormally small and the whole plant gradually dries up. All of the fruiting canes in a hill are about equally affected; in fact the whole plantation, if on fairly uniform soil, will be uniformly affected. Whereas, in the disease under discussion, canes die here and there with diseased canes and healthy canes occurring even in the small hill.

We are not prepared to say positively that the *Phoma* found on the affected canes is the cause of the disease because no inoculations with it have been made; but it is certainly to be regarded with suspicion. This disease is a worthy subject of investigation.[33]

LEAF SPOT.

(*Septoria rubi* Westd.)

Rare. Observed only at Poughkeepsie.

STRAWBERRY DISEASES.

DROUGHT.

Strawberries were damaged more by drought than by all diseases combined. The few persons so situated that they could irrigate their strawberries reaped a harvest of profit.

LEAF BLIGHT OR LEAF SPOT.

(*Sphaerella fragariae* (Tul.) Sacc.)

The situation with regard to this disease may be summed up in a phrase used by several of our correspondents; namely: "Severe on some varieties." It has not been nearly so virulent as in

33 The supposedly bacterial disease of Turner and Marlboro rasperries described by Freda Detmers, in Ohio Agr. Exp. Sta. Bul. 6, p. 128, seems to be different.

1898, but the more susceptible varieties have suffered considerably. It is well known that varieties differ greatly in their susceptibility to leaf blight. At Poughkeepsie the variety Gandy was severely attacked, while the variety Clyde growing in adjacent rows under parallel conditions was almost entirely exempt.

At Ghent we had an opportunity to observe the disastrous effect of leaf blight upon the crop of the following year. A row of Hunn stood beside a row of Parker Earle. In 1898 the Hunn blighted very severely while the Parker Earle was but slightly affected. On June 2, 1899, the Hunn promised a very trifling yield. Many of the plants did not even start in the spring. In marked contrast to the condition of the Hunn, the Parker Earle was making the best showing for a berry crop that we have ever seen.

It may be that some of our correspondents have confused the leaf spot caused by *Sphaerella fragariae* with that caused by *Ascochyta fragariae* Sacc. The two diseases resemble each other considerably, but the *Ascochyta* spots are redder and show minute black pimples at the center. On May 31 we collected fruiting specimens of the *Ascochyta* at Athens, Greene Co., but we do not believe that it was anywhere as abundant as the *Sphaerella.*

SUN-SCALD (?)

On June 2 we observed at Ghent a peculiar disease on the Hunn strawberry. The leaflets showed dead, brown V-shaped areas at their tips (see Plate XVI, fig. 2). These dead areas often extended half way down the midrib. They were generally situated at the tip of the leaflet, but occasionally occurred at the side. The disease occurred only on the Hunn, on which it was common but not destructive. It did not appear to be due to fungi and certainly not to insects. We are at a loss to account for it unless it may possibly have been a case of sun-scald.

REPORT

OF THE

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L. L. Van Slyke, Ph. D., *Chemist.*

Assistant Chemists.

C. G. Jenter, Ph. C.
W. H. Andrews,* B. S.
J. A. Le Clerc, B. S.
A. D. Cook,* Ph. C.
F. D. Fuller, B. S.
E. B. Hart,* B. S.
Chas. W. Mudge, B. S.

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I. Report of analyses of commercial fertilizers for the spring of 1899.

II. Report of analyses of commercial fertilizers for the fall of 1899.

III. Report of analyses of Paris green and other insecticides.

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* Connected with Fertilizer-Control.

REPORT OF THE CHEMIST.

I. REPORT OF ANALYSES OF COMMERCIAL FERTILIZERS FOR SPRING OF 1899.*

L. L. Van Slyke.

SUMMARY.

(1) Samples Collected. During the spring of 1899, the Station collected 866 samples of commercial fertilizers, representing 646 different brands. Of these different brands, 482 were complete fertilizers; of the others, 70 contained phosphoric acid and potash without nitrogen; 36 contained nitrogen and phosphoric acid without potash; 7 contained nitrogen only; 37 contained phosphoric acid alone; and 14 contained potash salts only.

(2) Nitrogen. The 482 brands of complete fertilizers contained nitrogen, varying in amount from 0.37 to 8.50 per ct., and averaging 2.04 per ct. The average amount of nitrogen found by the Station analysis exceeded the average guaranteed amount by 0.15 per ct., the guaranteed average being 1.89 per ct. and the average found being 2.04 per ct.

In 371 brands of complete fertilizers, the amount of nitrogen found was equal to or above the guaranteed amount, the excess varying from 0.01 to 2.27 per ct., and averaging 0.28 per ct.

In 111 brands the nitrogen was below the guaranteed amount, the deficiency varying from 0.01 to 1.78 per ct., and averaging 0.19 per ct. In 103 cases, the deficiency was less than 0.5 per ct.

The amount of water-soluble nitrogen varied from 0 to 4.43 per ct. and averaged 0.80 per ct.

* Partial reprint of Bulletin No. 160.

(3) Available Phosphoric Acid. The 482 brands of complete fertilizers contained available phosphoric acid varying in amount from 1.20 to 15.12 per ct. and averaging 8.76 per ct. The average amount of available phosphoric acid found by the Station analysis exceeded the average guaranteed amount by 0.98 per ct., the guaranteed average being 7.78 per ct. and the average found being 8.76 per ct.

In 418 brands of complete fertilizers, the amount of available phosphoric acid found was equal to or above the amount guaranteed, the excess varying from 0.03 to 6.32 per ct. and averaging 1.23 per ct.

In 64 brands, the available phosphoric acid was below the guaranteed amount, the deficiency varying from 0.02 to 3.68 per ct. and averaging 0.46 per ct. In 44 cases the deficiency was below 0.5 per ct.

The amount of water-soluble phosphoric acid varied from 0 to 10.28 per ct. and averaged 5.40 per ct.

(4) Potash. The complete fertilizers contained potash varying in amount from 0.43 to 12.95 per ct. and averaging 4.86 per ct. The average amount of potash found by the Station analysis exceeded the average guaranteed amount by 0.30 per ct., the guaranteed average being 4.56 per ct. and the average found being 4.86 per ct.

In 331 brands of complete fertilizers, the amount of potash found was equal to or above the guaranteed amount, the excess varying from 0.01 to 3.07 per ct. and averaging 0.59 per ct.

In 151 brands, the potash was below the guaranteed amount, the deficiency varying from 0.01 to 4.36 per ct. and averaging 0.50 per ct. In 105 of these cases, the deficiency was less than 0.5 per ct.

In 85 cases among the 482 brands of complete fertilizers the potash was contained in the form of sulphate free from an excess of chlorides.

(5) The retail selling price of the complete fertilizers varied from $17 to $45 a ton and averaged $26.66. The retail cost of

the separate ingredients, unmixed, averaged $18.28, or $8.38 less than the selling price.

INTRODUCTION.

NUMBER AND KINDS OF FERTILIZERS COLLECTED.

During the spring of 1899, the Station's collecting agents visited 165 towns between March 28 and June 29, obtaining 866 samples of commercial fertilizers. These samples represent 646 different brands, the product of 114 different manufacturers, each manufacturer being represented by from 1 to 39 brands.

The subjoined tabulated statement indicates the different classes included in the collection:

CLASSES OF FERTILIZERS COLLECTED.

Brands containing only nitrogen.	Brands containing only phosphoric acid.	Brands containing only potash.	Brands containing nitrogen and phosphoric acid without potash	Brands containing phosphoric acid and potash without nitrogen.	Brands of complete fertilizers.
7	37	14	36	70	482

COMPOSITION OF FERTILIZERS COLLECTED.

The following tabulated statement shows the average composition of the complete fertilizers collected during the spring, together with a comparison of the guaranteed composition and that found by analysis:

AVERAGE COMPOSITION OF COMPLETE FERTILIZERS COLLECTED.

	Per cent guaranteed.			Per cent found.			Average per ct. found above guarantee.
	Lowest.	Highest.	Average	Lowest.	Highest.	Average.	
Nitrogen	0.39	8.25	1.89	0.37	8.50	2.04	0.15
Available phosphoric acid	1.93	14.00	7.78	1.20	15.12	8.76	0.98
Insoluble phosphoric acid	....	.....	....	0.13	10.80	2.22	....
Potash	0.75	15.00	4.56	0.43	12.95	4.86	0.30
Water-soluble nitrogen	....	.....	....	0.00	4.43	0.80	....
Water-soluble phosphoric acid	....	.....	....	0.00	10.28	5.40	....

TRADE VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

The trade values in the following schedule have been agreed upon by the Experiment Stations of Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Vermont, as a result of study of the prices actually prevailing in the large markets of these states.

These trade values represent, as nearly as can be estimated, the average prices at which, during the six months preceding March, the respective ingredients, *in the form of unmixed raw materials,* could be bought at retail for cash in our large markets. These prices also correspond (except in case of available phosphoric acid) to the average wholesale prices for the six months preceding March plus about 20 per ct. in case of goods for which there are wholesale quotations.

TRADE VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

	1899. Cts. per pound.
Nitrogen in ammonia salts	15
Nitrogen in nitrates	12½
Organic nitrogen in dry and fine-ground fish, meat and blood, and mixed fertilizers	14
Organic nitrogen in cotton-seed meal and castor-pomace	12
Organic nitrogen in fine-ground bone and tankage	14
Organic nitrogen in coarse bone and tankage	10
Phosphoric acid, water-soluble	4½
Phosphoric acid, citrate-soluble	4
Phosphoric acid in fine-ground fish, bone and tankage	4
Phosphoric acid in coarse fish, bone and tankage	2
Phosphoric acid in cotton-seed meal, castor-pomace and wood ashes	4
Phosphoric acid in mixed fertilizers, insoluble in ammonium citrate and water	2
Potash as high-grade sulphate, in forms free from muriates (chlorides), in ashes, etc.	5
Potash in muriate	4¼

COMPARISON OF SELLING PRICE AND COMMERCIAL VALUATION.

Giving to the different constituents the values assigned in the schedule for mixed fertilizers, 14 cents a pound for nitrogen, 4½

cents a pound for water-soluble phosphoric acid, 4 cents a pound for citrate-soluble phosphoric acid, 2 cents a pound for insoluble phosphoric acid, and 4¼ cents a pound for potash, we can calculate the commercial valuation, or the price at which the separate unmixed materials contained in one ton of fertilizer, having the composition indicated in the preceding table, could be purchased for cash at retail at the seaboard. Knowing the retail prices at which these goods were offered for sale, we can also readily estimate the difference between the actual selling price of the mixed goods and the retail cash cost of the unmixed materials; the difference covers the cost of mixing, freight, profits, etc. We present these data in the following tables:

COMMERCIAL VALUATION AND SELLING PRICE OF COMPLETE FERTILIZERS.

Commercial valuation of complete fertilizers.	Selling price of one ton of complete fertilizer.			Averaged increased cost of mixed materials over unmixed materials for one ton.
Average.	Lowest.	Highest.	Average.	
$18.28	$17	$45	$26.66	$8.38

COST OF ONE POUND OF PLANT FOOD IN FERTILIZERS AS PURCHASED BY CONSUMERS.

In the table below we present figures showing the average cost to the purchaser of one pound of plant-food in different forms in mixed fertilizers:

AVERAGE COST OF ONE POUND OF PLANT-FOOD TO CONSUMERS IN MIXED FERTILIZERS.

Nitrogen	20.4 cents.
Phosphoric acid (available)	6.2 cents.
Potash	6.2 cents.

NEW FERTILIZER LAW.

The last State legislature amended the fertilizer law and attention is called to the principal changes that affect manufacturers and dealers.

(1) All fertilizers selling for *five* dollars or more per ton will come under the law, the limit previously having been confined to fertilizers selling for *ten* dollars or more per ton.

(2) Every manufacturer, importer, dealer or agent must pay a license fee amounting to *twenty* dollars a year for each separate brand or kind of fertilizer or fertilizing material.

(3) Statements of guarantee analysis, etc., are to be filed and license fees paid *during December* each year, covering the goods to be sold during the year following.

LAWS OF NEW YORK.

CHAPTER 955, LAWS OF 1896, AS AMENDED BY CHAPTER 687, LAWS OF 1899.

[Law is given as amended — changes in italics.]

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Statement of amount, brand name, manufacturer's name and address, and chemical composition required on each package.

Section 1. Every person who shall sell, offer or expose for sale in this State any commercial fertilizer or any material to be used as a fertilizer, the selling price of which exceeds *five* dollars per ton, shall stamp on or affix to each package of such fertilizer, in a conspicuous place on the outside thereof, a plainly printed statement which shall certify as follows:

1. The number of net pounds of fertilizer in the package sold or offered for sale;

2. The name, brand or trade-mark under which the fertilizer is sold;

3. The name and address of the manufacturer of the fertilizer;

4. The chemical composition of the fertilizer expressed in the following terms:

(a) Per centum of nitrogen;

(b) Per centum of available phosphoric acid, or in case of undissolved bone, the per centum of total phosphoric acid;

(c) Per centum of potash soluble in distilled water.

If any such fertilizer be sold, offered or exposed for sale in bulk, such printed statement shall accompany every part and parcel so sold, offered or exposed for sale.

Falsity in statement and deficiency in percentage composition violate provisions of act.

§ 2. It shall be a violation of the provision of this act if the statement required by section one of this act shall be false in regard to the number of net pounds of fertilizer in the package sold, offered or exposed for sale, or in the name, brand or trade-mark under which the fertilizer is sold, or in the name and address of the manufacturer of the fertilizer. It shall also be a violation of the provisions of this act if any commercial fertilizer or material to be used as a fertilizer shall contain a smaller percentage of nitrogen, phosphoric acid or potash than is certified in said statement to be contained therein, when such deficiency shall be greater than one-third of one per centum of nitrogen, or one-half of one per centum of available phosphoric acid (or one per centum of total phosphoric acid in the case of undissolved bone), or one-half of one per centum of potash soluble in distilled water.

Filing of statement required; license fee of twenty dollars per brand required; certificate given; fees go to treasurer of State; report of expenditures for analytical work required.

§ 3. Before any commercial fertilizer or any material to be used as a fertilizer is sold, offered or exposed for sale in this state, the manufacturer, importer or person who causes the same to be sold, offered or exposed for sale shall file with the New York Agricultural Experiment Station at Geneva, a certified copy of the statement prescribed in section one of this act, and, in addition, such

statement shall be filed thereafter annually during the month of *December. Each manufacturer, importer or person, before selling, offering or exposing for sale in this state any brand of commercial fertilizer, shall annually, during the month of December, pay to the treasurer of the New York Agricultural Experiment Station a license fee of twenty dollars for each and every brand of fertilizer, bearing a distinctive name, brand or trade mark, which said manufacturer, importer or person is to sell, offer or expose for sale in this state during the calendar year next succeeding said payment, provided, always, that the placing of any new brand upon the market at any time during said calendar year shall be preceded by such payment. Each manufacturer, importer or person who has complied with the provisions of this act relative to filing the aforesaid certified statement and to the payment of the aforesaid license fee shall be entitled to receive a certificate from the director of said station setting forth said facts. Said treasurer shall pay all money received as aforesaid to the treasurer of the state of New York, which treasurer when said money is so appropriated, upon the audit of the board of control of said station and the order of the comptroller of the state of New York, shall pay the money so received, or so much of it as may be necessary, in maintaining the expenses of enforcing the provision of this act. Said board of control shall report annually the expenditures so incurred for salaries, laboratory expenses, chemical supplies, traveling expenses and printing.*

Presence of inert nitrogenous matter to be stated.

§ 4. No person shall sell, offer or expose for sale in this state leather or its products or other inert nitrogenous material in any form, as a fertilizer or as an ingredient of any fertilizer, unless an explicit printed statement of the fact shall be conspicuously affixed to every package of such fertilizer, and shall accompany every parcel or lot of the same.

Penalty for violation.

§ 5. Every person violating any of the provisions of this act shall forfeit and pay to the people of the state of New York the sum of one hundred dollars for every such violation.

Evidence, official.

§ 6. Every certificate duly signed and acknowledged of a chemist or other expert employed by the director of the New York Agricultural Experiment Station at Geneva relating to the analysis of any commercial fertilizer, or material to be used as a fertilizer, shall be presumptive evidence of the facts therein stated.

Prima facie evidence.

§ 7. The doing of anything prohibited by this act shall be evidence of the violation of the provisions of this act relating to the things so prohibited and the omission to do anything directed to be done shall be evidence of a violation of the provisions of this act relative to the things so directed to be done.

Director responsible for enforcement of provisions of act; prosecutions to be brought by attorney-general.

§ 8. The director of the New York Agricultural Experiment Station at Geneva is charged with the enforcement of the provisions of this act, and for this purpose, may employ agents, chemists and experts, and whenever he shall know or have reason to believe that any penalty has been incurred by any person for the violation of any of the provisions of this act, or that any sum has been forfeited by reason of any such violation, he shall report the said violation with a statement of the facts to the attorney-general, who pursuant to the provisions of chapter eight hundred and twenty-one of the laws of eighteen hundred and ninety-five may cause an action or proceeding to be brought in the name of the people for the recovery of the same.

Previous law repealed.

§ 9. Chapter four hundred and thirty-seven of the laws of eighteen hundred and ninety and chapter six hundred and one of the laws of eighteen hundred and ninety-four are hereby repealed.

Act in operation.

§ 10. This act shall take effect immediately.

[The detailed analyses of the samples collected are not reprinted in this report, as they cease to have value before the report is printed and distributed. — Director.]

REPORT OF ANALYSES OF COMMERCIAL FERTILIZERS FOR THE FALL OF 1899.*

L. L. VAN SLYKE.

SUMMARY.

(1) *Samples Collected.*— During the fall of 1899, the Station collected 138 samples of commercial fertilizers, representing 130 different brands. Of these different brands 101 were complete fertilizers; of the others, 15 contained phosphoric acid and potash without nitrogen; 3 contained nitrogen and phosphoric acid without potash; and 10 contained phosphoric acid alone.

(2) *Nitrogen.*— The 101 brands of complete fertilizers contained nitrogen varying in amount from 0.59 to 4.91 per ct. and averaging 1.65 per ct. The average amount of nitrogen found by the Station analysis exceeded the average guaranteed amount by 0.13 per ct., the guaranteed average being 1.52 per ct. and the average found being 1.65 per ct.

In 79 brands of complete fertilizers, the amount of nitrogen found was equal to or above the guaranteed amount, the excess varying from 0.01 to 1.35 per ct. and averaging 0.23 per ct.

In 22 brands, the nitrogen was below the guaranteed amount, the deficiency varying from 0.03 to 0.62 per ct. and averaging 0.21 per ct. In 18 cases, the deficiency was less than 0.5 per ct.

The amount of water-soluble nitrogen varied from 0.03 to 4.79 per ct. and averaged 0.62 per ct.

* Partial reprint of Bulletin No. 173.

(3) *Available Phosphoric Acid.*— The 101 brands of complete fertilizers contained available phosphoric acid varying in amount from 3.44 to 13.08 per ct. and averaging 9.04 per ct. The average amount of available phosphoric acid found by the Station analysis exceeded the average guaranteed amount by 0.74 per ct., the guaranteed average being 8.30 per ct. and the average found being 9.04 per ct.

In 87 brands of complete fertilizers, the amount of available phosphoric acid found was above the amount guaranteed, the excess varying from 0.03 to 3.28 per ct. and averaging 0.93 per ct.

In 14 brands, the available phosphoric acid was below the guaranteed amount, the deficiency varying from 0.04 to 2.64 per ct. and averaging 0.49 per ct. In 10 cases the deficiency was below 0.05 per ct.

The amount of water-soluble phosphoric acid varied from 0.40 to 10.80 per ct. and averaged 6.07 per ct.

(4) *Potash.*— The complete fertilizers contained potash varying in amount from 0.48 to 10.75 per ct. and averaging 4.30 per ct. The average amount of potash found by the Station analysis exceeded the average guaranteed amount by 0.22 per ct., the guaranteed average being 4.08 per ct. and the average found being 4.30 per ct.

In 74 brands of complete fertilizers, the amount of potash found was above the guaranteed amount, the excess varying from 0.01 to 2.75 per ct. and averaging 0.54 per ct.

In 27 brands, the potash was below the guaranteed amount, the deficiency varying from 0.01 to 3.72 per ct. and averaging 0.65 per ct. In 15 of these cases the deficiency was less than 0.5 per ct.

In 15 cases among the 101 brands of complete fertilizers the potash was contained in the form of sulphate free from an excess of chlorides.

(5) The retail selling prices of the complete fertilizers varied from $16.50 to $35.00 a ton and averaged $23.25. The retail

cost of the separate ingredients unmixed averaged $17.00, or $6.25 less than the selling price.

INTRODUCTION.

NUMBER AND KINDS OF FERTILIZERS COLLECTED.

During the spring and fall of 1899, the Station's collecting agents visited 210 towns, obtaining 1004 samples of commercial fertilizers. These samples represent 776 different brands, the product of 132 different manufacturers, each manufacturer being represented by from one to 39 brands.

The subjoined tabulated statement indicates the different classes included in the collection.

CLASSES OF FERTILIZERS COLLECTED IN 1899.

1899	Brands containing only nitrogen.	Brands containing only phosphoric acid.	Brands containing only potash.	Brands containing nitrogen and phosphoric acid without potash.	Brands containing potash and phosphoric acid without nitrogen.	Brands of complete commercial fertilizers.
Spring collection	7	37	14	36	70	482
Fall collection	0	10	1	3	15	101
Total for year	7	47	15	39	85	583

COMPOSITION OF FERTILIZERS COLLECTED IN 1899.

The tabulated statement below shows the average composition of the complete fertilizers collected during the year, together with a comparison of the guaranteed composition and that found by analysis.

AVERAGE COMPOSITION OF COMPLETE FERTILIZERS COLLECTED.

1899	Per ct. guaranteed. Lowest.	Per ct. guaranteed. Highest.	Per ct. guaranteed. Average.	Per ct. found. Lowest.	Per ct. found. Highest.	Per ct. found. Average.	Average per cent. found above guarantee.
Spring:							
Nitrogen	0.39	8.25	1.89	0.37	8.50	2.04	0.15
Available phosphoric acid	1.93	14.00	7.78	1.20	15.12	8.76	0.98
Insoluble phosphoric acid	....	.....	....	0.13	10.80	2.22	....
Potash	0.75	15.00	4.56	0.43	12.95	4.86	0.30
Water-soluble phosphoric acid	....	.....	....	0.00	4.43	5.40	....
Water-soluble nitrogen	....	.....	....	0.00	10.28	0.80	....
Fall:							
Nitrogen	0.41	4.95	1.52	0.59	4.91	1.65	0.13
Available phosphoric acid	3.55	11.00	8.30	3.44	13.08	9.04	0.74
Insoluble phosphoric acid	....	.....	....	0.63	9.64	2.24	....
Potash	1.00	10.00	4.08	0.48	10.75	4.30	0.22
Water-soluble phosphoric acid	....	.....	....	0.40	10.80	6.07	....
Water-soluble nitrogen	....	.....	....	0.03	4.79	0.62	....
Average for year:							
Nitrogen	....	.....	1.83	....	.....	1.97	0.14
Available phosphoric acid	....	.....	7.87	....	.....	8.80	0.93
Insoluble phosphoric acid	....	.....	....	....	.....	2.23	....
Potash	....	.....	4.48	....	.....	4.76	0.28
Water-soluble phosphoric acid	....	.....	....	....	.....	5.55	....
Water-soluble nitrogen	....	.....	....	....	.....	0.75	....

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

The trade-values in the following schedule have been agreed upon by the Experiment Stations of Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Vermont, as a result of study of the prices actually prevailing in the large markets of these states.

These trade-values represent, as nearly as can be estimated, the average prices at which, during the six months preceding March, the respective ingredients, *in the form of unmixed raw materials,*

could be bought at retail for cash in our large markets. These prices also correspond (except in case of available phosphoric acid) to the average wholesale prices for the six months preceding March plus about 20 per ct. in case of goods for which there are wholesale quotations.

TRADE VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

	1899. Cents per pound.
Nitrogen in ammonia salts	15
Nitrogen in nitrates	12½
Organic nitrogen in dry and fine-ground fish, meat and blood, and mixed fertilizers	14
Organic nitrogen in cotton-seed meal and castor-pomace	12
Organic nitrogen in fine-ground bone and tankage	14
Organic nitrogen in coarse bone and tankage	10
Phosphoric acid, water-soluble	4½
Phosphoric acid, citrate-soluble	4
Phosphoric acid in fine-ground fish, bone and tankage	4
Phosphoric acid in coarse fish, bone and tankage	2
Phosphoric acid in cotton-seed meal, castor-pomace and wood ashes	4
Phosphoric acid in mixed fertilizers, insoluble in ammonium citrate and water	2
Potash as high-grade sulphate, in forms free from muriates (chlorides), in ashes, etc.	5
Potash in muriate	4¼

COMPARISON OF SELLING PRICE AND COMMERCIAL VALUATION.

Giving to the different constituents the values assigned in the schedule for mixed fertilizers, 14 cents a pound for nitrogen, 4½ cents a pound for water-soluble phosphoric acid, 4 cents a pound for citrate-soluble phosphoric acid, 2 cents a pound for insoluble phosphoric acid, and 4¼ cents a pound for potash, we can calculate the commercial valuation, or the price at which the separate unmixed materials contained in one ton of fertilizer, having the composition indicated in the preceding table, could be purchased for cash at retail at the seaboard. Knowing the retail prices at which these goods were offered for sale, we can also readily estimate the difference between the actual selling price of

the mixed goods and the retail cash cost of the unmixed materials; the difference covers the cost of mixing, freight, profits, etc. We present these data in the following tables:

COMMERCIAL VALUATION AND SELLING PRICE OF COMPLETE FERTILIZERS.

1899.	Commercial valuation of complete fertilizers.	Selling price of one ton of complete fertilizer.			Average increased cost of mixed materials over unmixed materials for one ton.
	Average.	Lowest.	Highest.	Average.	
Spring	$18.28	$17.00	$45.00	$26.66	$8.38
Fall	17.00	16.50	35.00	23.25	6.25
Average for year	$18.06	$16.50	$45.00	$26.07	$8.01

COST OF ONE POUND OF PLANT FOOD IN FERTILIZERS AS PURCHASED BY CONSUMERS.

In the table below we present figures showing the average cost to the purchaser of one pound of plant-food in different forms in mixed fertilizers.

AVERAGE COST OF PLANT FOOD IN MIXED FERTILIZERS AS PURCHASED BY CONSUMERS.

1899.	One pound of nitrogen.	One pound of available phosphoric acid.	One pound of potash.
Spring	20.4	6.2	6.2
Fall	19.2	5.8	5.8
Average for year	20.2	6.1	6.1

[The detailed analyses of the samples collected are not reprinted in this report, as they cease to have value before the report is printed and distributed. — Director.]

REPORT OF ANALYSES OF PARIS GREEN AND OTHER INSECTICIDES.*

L. L. Van Slyke.

SUMMARY.

In accordance with the provisions of a law designed to protect purchasers of Paris green, samples were secured during 1899 and the results are published in this bulletin.

Paris green contains as its chief constituent a compound called copper aceto-arsenite, which, when chemically pure, contains

Arsenious oxide	58.64 per ct.
Copper oxide	31.30 "
Acetic acid	10.06 "

In the 24 samples of Paris green examined, the arsenious oxide varied from 55.34 to 60.16 per ct. and averaged 56.48 per ct. The copper oxide varied from 27.70 to 30.90 per ct., and averaged 29.97 per ct. The amount of arsenious oxide for each pound of copper oxide varied from 1.82 to 2.17 and averaged 1.88 pounds. The only adulterant that could be found was white arsenic and this was excessive in only one sample. The general result of the examination is to show a good quality of Paris green in the market at the time the samples were taken.

Partial analyses are given of the following materials: Paragrene, Black Death, Slug Shot, London Purple, Laurel Green, Smith's Electric Vermin Exterminator, Bug Death.

INTRODUCTION.

During the past ten years the use of Paris green has very rapidly increased, owing to its efficiency as an insecticide. There

* Reprint of Bulletin No. 165.

have been frequent complaints on the part of farmers that Paris green has proved inefficient in so many instances as to lead to serious suspicions in regard to its purity. As a result of such complaints, the State legislature, in March, 1898, passed a law intended to prevent fraud in the sale of Paris green; but no appropriation was made for the enforcement of the provisions of the law and no work was done until 1899.

During 1899 samples of Paris green were collected and the results of analysis of these samples are presented in this bulletin. Some materials were collected which were found in the market as insecticides, but which contained little or no Paris green. A general statement of the composition of these will also be given, as information of this kind is often desired.

CHEMICAL COMPOSITION OF PARIS GREEN.

There is more or less confusion as to the exact chemical compound that goes under the name of Paris green. Many chemical writers include two different arsenic compounds under this name, but the compound most frequently met in commerce contains *copper, arsenic* and *acetic acid,* and is chemically known as *copper aceto-arsenite;* in the trade this compound, in a form not chemically pure, is known as Paris green, Schweinfurt green, Imperial green, French green, Emerald green, etc.

Paris green, or copper aceto-arsenite, when chemically pure, contains the following amounts of the different elements indicated:

Arsenic	44.44	per ct.
Copper	24.99	"
Oxygen	25.25	"
Carbon	4.73	"
Hydrogen	0.59	"

Paris green may be regarded as approximately consisting of —

Copper arsenite	82	per ct.
Copper acetate	18	"

However, it is customary, in speaking of the amount of arsenic contained in Paris green, to refer to it as *arsenious oxide;* and, using this form of expression, we would give the composition of pure copper aceto-arsenite as follows:

Arsenious oxide	58.64	per ct.
Copper oxide	31.30	"
Acetic acid	10.06	"

Paris green, as found in commerce, rarely, if ever, consists of pure copper aceto-arsenite, but contains this compound as its chief constituent with varying proportions of other substances.

In the compound copper aceto-arsenite, there are, for each pound of copper oxide, 1.87 pounds of arsenious oxide.

ANALYSES OF SAMPLES OF PARIS GREEN.

Sample number.	Name of Manufacturer.	Brand or trade name.	Place where sample was taken.	Arsenious oxide.	Copper oxide.
22	Adler Color and Chemical Works, 100 William street, New York city	Paris green	West Valley	56.02	29.35
12	Do.	Paris green	Angelica	55.34	28.55
1*	A. B. Ansbacher & Co., 4 Murray street, New York city	Paris green	Holcomb	56.55	30.54
30	Do.	Paris green	Rochester	55.89	30.35
8*	P. Becker & Co., Buffalo, N. Y.	Paris green	Black Creek	56.15	30.45
21*	O. W. Clark & Son, Buffalo, N. Y.	Paris green	East Aurora	56.65	29.90
4*	F. W. Devoe & C. T. Reynolds Co., corner Fulton and William streets, New York city	Paris green	Holcomb	56.65	30.44
11*	Do.	Paris green	Angelica	56.15	30.40
3	Hamden Paint and Chemical Co., Springfield, Mass.	Paris green	Holcomb	57.03	30.06
27	Do.	Paris green	Jamestown	56.15	30.75
14	Morris Hermann & Co., 255 Pearl street, New York city	Paris green	Friendship	60.16	27.70
31*	Highlands Chemical Co., 100 William street, New York city	Paris green	Friendship	56.15	28.95
15*	Fred L. Lavanburg, 165 William street, New York city	Paris green	Rochester	56.55	29.80
18*	Geo. E. Lavereck, Buffalo, N. Y.	Paris green	Franklinville	56.28	29.95
6*	Leggett & Brother, 30 Pearl street, New York city	Paris green	Canandaigua	56.55	29.75
29	Do.	Paris green	Rochester	56.15	30.10
10	Lewis Berger & Sons, 248 Front street, New York city	Paris green	Black Creek	58.15	28.90

24*	Maltby Chemical Co., Buffalo, N. Y.	Paris green	Cattaraugus	56.28	30.90
23*	I. Pfeiffer, 174 Fulton street, New York city	Paris green	Little Valley	55.89	30.55
5	Sondheim, Alsberg & Co., New York city	Paris green	Canandaigua	56.16	29.81
2*	Not given	Paris green	Holcomb	56.31	30.35
9*	Not given	Paris green	Black Creek	56.15	30.55
13*	Not given	Paris green	Friendship	56.65	30.65
16*	Not given	Paris green	Friendship	55.58	30.50

* Dissolved completely and easily in strong ammonia.

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DISCUSSION OF RESULTS OF ANALYSIS.

1. In the 24 samples of Paris green examined, the amount of arsenious oxide varied from 55.34 to 60.16 per ct. and averaged 56.48 per ct. This average is only about 2 per ct. below the arsenious oxide contained in pure copper aceto-arsenite and indicates a good quality of Paris green, so far as the arsenic content is concerned. Excepting one or two samples that run high in arsenic, the variation is surprisingly small. The legal requirement is 50 per ct. arsenious oxide.

2. The amount of copper oxide varies from 27.70 to 30.90 per ct. and averages 29.97 per ct., which is one and one-third per ct. below that in pure copper aceto-arsenite. The copper content therefore indicates a good quality of Paris green.

3. In pure copper aceto-arsenite there are 1.87 pounds of arsenious oxide for one pound of copper oxide. Now, this relation is of value in showing whether Paris green contains more arsenious oxide than it ought. The chief adulterant used in Paris green is arsenious oxide, commercially known as white arsenic. This is used because it is cheaper than Paris green and also because it can be safely added without any danger of reducing the amount of arsenious oxide. In fact, a very poor quality of Paris green can be brought up to the legal requirements by addition of arsenious oxide. However, arsenious oxide cannot be added to Paris green without increasing the ratio of arsenious oxide to copper oxide above 1.87. In the samples examined, the ratio of arsenious oxide to copper oxide varies from 1.82 to 2.17 and averages 1.88. In sample No. 14, the arsenious oxide exceeds 60 per ct. and the copper is less than 28 per ct.; hence, the arsenious oxide is present in amounts more than twice exceeding the copper oxide. In other words, there is too much arsenious oxide for the copper oxide present and the only possible inference is that white arsenic has either been added purposely or is present as the result of carelessness in manufacture.

4. The solubility of Paris green in strong ammonia is a fair test of purity, so far as concerns the addition of white arsenic and insoluble adulterants, like barium sulphate, calcium sulphate, etc. In the table above we have indicated those samples that dissolved easily and completely in strong ammonia, making a perfectly clear solution without sediment. These samples were free from white arsenic. Fifteen samples dissolved satisfactorily, while nine samples did not dissolve completely at once, but only on standing for a considerable time, and even then traces remained undissolved.

5. In general, it may be said that the results of our work indicate a very satisfactory condition as to the purity of the Paris green in the market. They do not justify the widespread belief that Paris green is extensively and seriously adulterated. In every instance the arsenious oxide considerably exceeds the legal requirements. The only material that we have found used as an adulterant is white arsenic and this in only one or two cases. In not a single case have we found such materials as sulphates of barium, calcium, etc.

6. The color of Paris green is changed to such an extent by addition of white arsenic or other similar materials that one can usually detect an adulterated article by its appearance. Paris green of good quality is intensely bright green and uniform. When adulterated, the green loses something of its intensity and is grayish green and is not always uniform.

EXAMINATION OF MISCELLANEOUS INSECTICIDES.

PARAGRENE.

Two samples of this material were secured, one at Jamestown and one at Geneva. One sample contained 43.34 per ct. arsenious oxide and 18.08 per ct. copper oxide; and the other 52.30 per ct. arsenious oxide and 21.64 per ct. copper oxide. The arsenic is present in combination with calcium as calcium arsenite to some extent. The material is a proprietary article and is not put on the market as a Paris green. From the results obtained

with the two samples examined, it appears to be very variable in composition. Paragrene is manufactured by Fred L. Lavanburg, 165 William St., N. Y. City.

BLACK DEATH.

This material is made by the Oatka Chemical Co., Mumford, N. Y. The sample examined was obtained at Canandaigua. It consists largely of sulphate of lime or gypsum. It contains a very small amount of arsenic and some organic matter not determined.

SLUG SHOT.

This is manufactured by Benjamin Hammond, Fishkill-on-Hudson, N. Y. The sample examined was secured at Cuba. The material is largely sulphate of lime and silica, with small amounts of copper and arsenic compounds.

LONDON PURPLE.

London purple is a by-product in manufacture of dyes. It is very variable in composition. The arsenic is present chiefly as a calcium arsenite. The sample examined was found at East Aurora, and came from Hemmingway's London Purple Co., London and New York. It contained 32.88 per ct. arsenious oxide.

LAUREL GREEN.

This is made by the Nichols Chemical Co., New York, and the sample examined was found at East Aurora. It was found to contain 3.83 per ct. arsenious oxide and 11.50 per ct. copper oxide with large amounts of calcium carbonate and calcium hydoxide (slaked lime).

SMITH'S ELECTRIC VERMIN EXTERMINATOR.

This is made by Fernando B. Smith, Canton, O. The sample was taken at Jamestown. It appears to be mainly a mixture of calcium carbonate and calcium hydroxide (slaked lime) with a very small amount of organic matter.

BUG DEATH.

This is put on the market by the Danforth Chemical Co., Leominster, Mass. The sample examined was taken at Medina. It consists largely of the oxides of zinc, lead and iron. It contains some phosphorus.

PRESENT LAW DEFECTIVE.

The law in its present condition is seriously defective, as it fails totally to protect purchasers from adulteration of Paris green with reference to the only material that we have found commonly used as an adulterant, and that is white arsenic. As the law now stands, there is nothing to prevent the addition of any amount of white arsenic to Paris green. The law also fails to define Paris green. In order to make the law really efficient, Paris green should be legally defined and the amount of copper should be taken into consideration as well as the amount of arsenious oxide. It is a matter of congratulation and surprise that with so loosely constructed a law there should be found such a satisfactory condition in the Paris green samples found in the market.

LAW TO PREVENT FRAUD IN THE SALE OF PARIS GREEN.

LAWS OF NEW YORK.— CHAP. 113.

AN ACT to amend the agricultural law, to prevent fraud in the sale of Paris green.

Became a law March 23, 1898, with the approval of the Governor. Passed, three-fifths being present.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. Chapter three hundred and thirty-eight of the laws of eighteen hundred and ninety-three, entitled "An act in relation to agriculture, constituting articles one, two, three, four and five, of chapter thirty-three of the general laws," is hereby

amended by adding a new article to be known as article eight and to read as follows:

ARTICLE VIII.

Section 110. State manufacturer and the dealer in original packages to file certificate with commissioner of agriculture.
111. Certificate to be given by commissioner of agriculture to state manufacturer and dealer in original packages.
112. Composition of Paris green.
113. Paris green to be analyzed at experiment station.
114. Penalty for violations.

Section 110. State manufacturer and the dealer in original packages to file certificate with commissioner of agriculture.— After the passage of this act it shall be the duty of each and every manufacturer of Paris green within this state, and of every dealer in original packages of Paris green manufactured outside of this state, before the said Paris green is offered or exposed for sale or sold within this state, to submit to the commissioner of agriculture a written or printed statement setting forth: first, the brands of Paris green to be sold, the number of pounds contained in each package in which it is put upon the market for sale, the name or names of the manufacturers and the place of manufacturing the same; second, the statement shall set forth the amount of arsenic which the said Paris green contains, and the statement so furnished shall be considered as constituting a guarantee to the purchaser that every package of such Paris green contains not less than the amount of arsenic set forth in the statement.

§ 111. Certificate to be given by the commissioner of agriculture to state manufacturer and dealer in original packages.— Every purchaser of Paris green in original packages, which is manufactured outside of this state, who intends to sell or expose the same for sale, and every manufacturer of Paris green within this state shall, after filing the statement above provided for, with

the commissioner of agriculture, receive from the said commissioner of agriculture, a certificate stating that he has complied with the foregoing statement, which certificate shall be furnished without any charge therefor; said certificate when furnished shall authorize the party receiving the same to deal in this state in Paris green. Any person who fails to file the statement aforesaid shall not be entitled to such certificate and shall not be entitled to deal in Paris green within this state; nothing in this section shall be construed as applying to retail dealers.

§ 112. Composition of Paris green or analogous products.— Paris green, or any product analogous to it, when sold, offered or exposed for sale, as such, in this state, shall contain at least fifty per centum of arsenious oxide.

§ 113. Paris green to be analyzed at experiment station.— The director of the New York state agricultural experiment station, at Geneva, shall, under the direction of the commissioner of agriculture, examine, or cause to be examined, the different brands of Paris green, sold, offered or exposed for sale, within the state, and cause samples of the same to be analyzed, and shall report the result of the analysis forthwith to the commissioner of agriculture.

§ 114. Penalty for violations.— Any person or persons, firm, association, company or corporation violating any of the provisions of this act, shall be guilty of a misdemeanor, and shall be fined not less than fifty dollars nor more than two hundred dollars; and in addition thereto shall forfeit and pay unto the people of the state of New York the sum of one hundred dollars, together with the costs of the suit in an action caused to be brought by the commissioner of agriculture in the name of the people of the state of New York, as provided by section eight of the agricultural law.

§ 2. This act shall take effect immediately.

List of Parties Who Have Received Paris Green Certificates.

No. 1. June 21, 1898, F. W. Devoe & C. T. Reynolds Co., cor. Fulton and William streets, N. Y. city.

No. 2. June 21, 1898, Fred. L. Lavanburg, No. 165 William street, N. Y.

No. 3. June 21. 1898, Adler Color and Chemical Works, No. 96 and 98 Maiden Lane, N. Y.

No. 4. June 21, 1898, Lewis Berger & Sons, Ltd., No. 248 Front street, N. Y.

No. 5. July 5, 1898, Morris Hermann & Co., No. 255 Pearl street, N. Y.

No. 6. July 5, 1898, I. Pfeiffer, No. 174 Fulton street, N. Y.

No. 7. July 7, 1898, Highlands Chemical Co., Eugene Waugh, Treas., No. 100 William street, N. Y.

No. 8. July 7, 1898, A. B. Ansbacher & Co., No. 4 Murray street, N. Y.

No. 9. July 7, 1898, Leggett & Brother, No. 301 Pearl street, N. Y.

No. 10. July 9, 1898, Rogers & Pyatt, No. 78–80 Maiden Lane, N. Y.

No. 11. July 11, 1898, Eckstein Brothers, No. 259 Pearl street, N. Y.

No. 12. July 13, 1898, James H. Blanchard, No. 125 Broad street, N. Y.

No. 13. July 13, 1898, Commercial Chemical Co. of the U. S., No. 253 Broadway, N. Y.

No. 14. July 20, 1898, John Lucas, No. 89 Maiden Lane, N. Y.

No. 15. February 16, 1899, Chas. M. Childs & Co., No. 225 Pearl street, N. Y.

No. 16. March 8, 1899, The Bulman-Warner Paint Co., 76 to 84 Ninth street, Brooklyn, N. Y.

No. 18. May 16, 1899, I. Pfeiffer, No. 174 Fulton street, N. Y.

No. 19. May 16, 1899, Fred. L. Lavanburg, No. 165 William street, N. Y.

No. 20. May 16, 1899, James A. Blanchard, No. 125 Broad street, N. Y.

No. 21. May 16, 1899, Lewis Berger & Sons, No. 248 Front street, N. Y.

No. 22. May 18, 1899, Adler Color & Chemical Works, No. 100 William street, N. Y.

No. 23. May 18, 1899, John Lucas & Co., No. 89 Maiden Lane, N. Y.

REPORT

OF THE

Department of Entomology.

V. H. LOWE, *Entomologist.*
F. A. SIRRINE, *Entomologist.**

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* At Second Judicial Department Branch Station, Jamaica, Long Island.

REPORT OF THE ENTOMOLOGISTS.

COMBATING THE STRIPED BEETLE ON CUCUMBERS.*

F. A. SIRRINE.

SUMMARY.

The striped cucumber beetle[1] in one form or another is injurious to cucumber, melon, and squash vines, from the time the vines start in the spring until the plants are killed by frost.

Only one brood of the beetles occurs during a year on Long Island, but the adults of this brood are injurious at two periods of their lives; in the fall and again, after hibernating in the ground below frost line, in early summer of the next season. The larvæ require moist earth to live in. They feed upon the stems and fruits wherever these come in contact with moist soil.

The striped cucumber beetle cannot be controlled by any one remedy or preventive measure. No remedies can be used to hinder the work of the beetle on the flowers, nor can the work of the larvæ on and within the stems and fruits be prevented. The following combination of remedies and preventive measures is recommended for large fields: First, planting squashes on the margins of the field previous to planting the cucumbers or melons;

* Reprint of Bulletin No. 158.

1 This pest is wrongly called the "striped bug." It is not a bug, but a beetle, having hard wing-covers. Long Island farmers call it the "cuck beetle," which is more appropriate than "striped bug," or even "cucumber bug."

second, dusting part of the squashes with green arsenite (copper arsenite), combined with spraying the cucumbers or melons with Bordeaux mixture, 1-to-11 formula. For garden patches are recommended: First, planting squashes on the margins of the patch previous to planting the cucumbers or melons; second, dusting part of the squashes with green arsenite, combined with the use of covers over the plants. For fall treatment, either squashes or beans should be planted on the cucumber or melon fields during September, and as soon as the beetles are found feeding upon them, dust the plants with green arsenite.

INTRODUCTION.

Although the striped cucumber beetle has been described and figured, and some remedies for it have been given by Mr. Lowe in Bulletin No. 75 of this Station, results obtained from attempts to control the pest on a large scale in the pickle-growing sections of Long Island, during the past two years, warrant the publication of a separate bulletin. Furthermore, the economic importance of this pest, not only in the market garden sections but throughout the whole State, makes it advisable that farmers should be kept posted as to the best up-to-date methods of controlling its ravages, so that even frequent repetition of old measures is pardonable. In addition, some new facts regarding the life, history and habits have been obtained, which progressive farmers can use to advantage and thus avoid applying remedies at random.

THE STRIPED CUCUMBER BEETLE.

Diabrotica vittata Fab.

Order COLEOPTERA; family CHRYSOMELIDAE.

HISTORY.

The striped cucumber beetle is distinctively a native American pest. It occurs in all parts of the country east of the Rocky Mountains and is always on hand to feed upon squashes, melons

and cucumbers over this whole region, whether planted in small gardens or in large fields.

The earliest record we have of the injuries of this pest was published in 1843 by William Gaylord.[2]

As early as 1864, Dr. Fitch[3] tells us that he has had to use some means for protecting his cucumber vines from the "cucumber bug" for more than twenty years. In 1852, Dr. Harris[4] describes the work of the "striped bug," giving a long list of remedies and stating that a Mr. Levi Bartlett of Warner, N. H., has presented a method of making frames to be covered with millinet for placing over the vines .

INJURY.

Usually farmers complain only of the work of the striped beetle on cucumber, melon, and squash vines at the time the vines are coming out of the ground. Probably the harm done at this time causes the largest amount of loss, but nearly as much damage is produced later by the beetles gnawing the stems of the vines and by their feeding on the flowers; the former weakening the vines and the latter preventing the setting of fruit. Some damage is caused by the larvæ, or grubs, feeding on and within the stems of the vines, but probably no more harm is done to the vine itself by the larvæ, than is done to the fruit, especially of the muskmelon and squash. The larvæ feed upon the rind of the fruits, mining into them, making them rough and warty and producing conditions which afford an excellent foothold for various rots and bacterial diseases. The amount of real wilting of vines, due to the work of the larvæ alone, is slight, but the mining of the stems at or near the roots weakens the vines and aids the work of diseases.

At the time of the appearance of the new brood of beetles, there is little chance for them to injure the old, tough vines, but

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2 Trans. N. Y. State Agr. Soc., 1843: 127–174.

3 Tenth Report on the Noxious and Other Insects of the State of New York.

4 Insects Injurious to Vegetation: 124–126. (Flint's ed., 1852.)

they do cause considerable damage to the fruit itself. They will gnaw away the rind from immature fruits, while on mature cantaloupes they eat holes through the rind and then devour the flesh. This injury to the fruit of muskmelons is very noticeable in market garden sections, especially where there are but few wild flowers, such as golden rod and aster, for the insects to feed upon. The injury they do in the fall is not confined to the fruits of the melon; they often attack late planted beans, devouring not only the leaves, but also the tender pods.

Thus it is seen that this little pest is busy devouring our crops from late spring until driven into winter quarters by freezing weather. In ages past, before they had cultivated crops to eat, they fed upon a few wild species of the gourd family and upon the pollen and flowers of many other plants. They still have this habit of feeding upon the pollen and flowers of plants, but we have no means of estimating the amount of damage done in this way nor have we means of preventing it.

FOOD PLANTS.

It is well known that the striped beetle feeds not only on cucumber, muskmelon, and squash vines, but also on all related *Cucurbitaceae.* In early spring I have found them feeding on the flowers of wild cranesbill (*Geranium maculatum*). In the fall of the year they have been found feeding on the flowers of golden rod and sunflowers. They are also known to feed on beans, peas, and the tassels, silk and kernels of corn. They are said to feed on the flowers of the apple, chokeberry, Juneberry, cherry and related plants, also on the wild balsam apple (*Echinocystis lobata*).

HABITS AND LIFE HISTORY.

Beetle.— On Long Island the adult beetles issue from their winter quarters in the ground at various times between the middle of April and the first of June. During 1897 no beetles were taken

until May 18, while in 1898 none were found until May 30, and during both 1897 and 1898 the adult beetles did not appear in injurious numbers until about June 10. The solitary specimens seen during the latter part of April and even during May appear to be stragglers looking for something to devour. The chances are that these early beetles are so fortunate as to find winter quarters in buildings and under rubbish where they do not have to go so deep into the soil to be beyond the reach of frost as do those that hibernate in the open fields. For this reason we frequently find them during warm days in April and May.

Both males and females feed ravenously for five or ten days (June 5 to 15) after which they commence to mate. Previous to pairing and especially during the first three or four days of their feeding period they eat tender and tough, clean and dirty, and even poisoned leaves and stems. If food is scarce, they will eat cucumber, squash, and melon plants off down to the roots, and dig after those that are not yet out of ground. During this period they also show a decided preference for the squash. Even where the squashes are planted in the same hill with cucumbers or muskmelons the beetles will devour the squashes first.

After their first ravenous appetite is satisfied and they have commenced pairing, they do less feeding and are more particular as to what they eat; feeding then only on the more tender parts of the vines, especially the flowers. At this time they absolutely refuse to feed on any part of the vine that may bear foreign substance on its surface. This habit makes it impossible to kill them with a poison after pairing commences. They will not always leave the treated vines, but do their feeding on the growing tips of the vine and on the flowers. All poisons should, therefore, be applied before pairing commences.

Pairing continues until the middle of August, even though egg laying may have ceased a month before. The tendency to pair is so strong in the males that I have even found them attached to the females of the twelve-spotted beetle.

Egg.—According to observations made in the field during 1898,

egg-laying begins about July 20, but dissections show that the deposition of eggs could begin the latter part of June and that it ceases entirely by the last of July. Hence, the egg-laying period of the beetles, in this section, extends over about one month. It is not known for how long a period an individual beetle continues to deposit eggs, but this period surely varies in different individuals. Specimens in confinement and excited, deposited a large number of eggs in a few hours; many of which were in clusters. In all field observations the eggs have been found deposited singly.

Some writers have stated that the eggs are deposited in the soil and on the stems near the roots. In only one instance have I been able to find an egg near the roots; this was found in a cavity in the stem where the beetle had been feeding. I have frequently found the eggs caught in the hairs of the leaves at the growing tips of the vines. This, together with the fact that very few larvæ compared with the number of beetles which appear in the fall, are found in the stems, especially of muskmelons; and considering that the larvæ have been found feeding on the rind of the fruits of muskmelons, indicates that the eggs are usually dropped wherever the beetle happens to be feeding. Hence, they are just as liable to be dropped on the ground as on the surface of a leaf. Probably the eggs are laid during the middle of the day, and, as the beetles go to the underside of the leaves and even crawl under the vines to find shade, the eggs are generally deposited in these places.

In 1864, Dr. Fitch[5] stated that the eggs are dropped on the ground. A number of other writers state that the eggs are probably deposited below the surface of the ground on the roots of the vines. If these writers are correct in their assumption, the beetles vary considerably in their habits of depositing eggs. The length of time required for the egg to hatch is not known.

Larvae.—According to Dr. Henry Shimer,[6] the larva or grub

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[5] Tenth Report on Noxious and Other Insects: 439.

[6] *Prairie Farmer.* August 12, 1865.

requires a month from the time it hatches to obtain its full size. In general, persons who have written anything regarding the striped beetle, since Dr. Shimer's observations were made, have given the same period for the development of the larva. As shown by the author's dissection of female beetles, the egg-laying period can extend from June 20 until the last of July. I have collected half-grown larvæ as early as July 10 and found larvæ still at work as late as September 17; hence, if the eggs are all deposited by the last of July, some of the larvæ must require two months to complete their growth. Probably the length of the larval period depends on the food supply.

F. H. Chittenden[7] says: "The larval period is passed in the earth, at the base of the stalks, and larvæ are often found within the stems above ground."

I have very rarely found the larvæ within the stems of muskmelon, which is apparently too woody for them to penetrate. They are frequently found in the stems of cucumber and squash, but I have not found them in such numbers in these places as upon the rind of the muskmelon fruit where the latter comes in contact with the moist earth. I have also found them working on squash and ripe cucumbers in the same places. In a few instances I have been seen them working on the lower surface of squash vines where the latter come in contact with moist earth. Close examination will reveal the fact that cucumber, squash, and melon vines appear to be eroded at other points besides where they are attached to the root and frequently the fruits will have the same appearance. This is all caused, probably, by the larvæ of the striped cucumber beetle and of the twelve-spotted beetle, where both occur. It surely is their work at the base of the plants and on the fruits of the muskmelon. Hence the statement that the larval period is passed in the earth at the base of the stalks is partially correct, but all facts would be covered better by

[7] U. S. Dept. Agr., Div. Ent., Bul. No. 10, n. ser.: 28.

stating that the larvæ of the striped cucumber beetle require moist earth to live in and that they feed upon the vines and fruit of the squash, melon and cucumber wherever the latter come in contact with the moist earth. Possibly they feed upon the roots proper, but we have no direct proof of this.

Pupa.— Mr. Chittenden has proven that the pupal or resting stage can be passed in seven days. A number of writers have stated that the pupal stage lasts two weeks. The larva forms an earthen cell in which it changes to a pupa, but does not form a cocoon as stated by some.

Hibernation.—According to Dr. Shimer[8] and Mr. Saunders[9] the striped cucumber beetle passes the winter in the pupal state. This is a mistake, as more recent investigations show that they pass the winter as adult beetles as does the potato beetle. Like the latter they go below the frost line to hibernate.

Number of broods.— Most of the writers to whose work I have access, state that there are several broods of the beetles each year. It is true that the beetles occur in large numbers in the spring and again in the fall, and if the statement that they hibernate as pupæ is correct, then the statement that there are at least two broods each year would be correct also. My field notes show that the beetles begin to decrease in numbers toward the end of July, but do not all disappear until September, and sometimes not until the new brood of beetles appears. Thus beetles can be found throughout the entire summer and fall. In fact, during July, August and September of 1898 I was able to collect beetles every week. The dissections indicate that the beetles collected during August and the first half of September were mostly males and diseased or imperfect females. The dissections of the females of the new brood show also that the reproductive organs are not developed and do not develop even as late as the middle of October. Furthermore, by the dissections it was shown that a large amount of fatty tissue is formed preparatory to hibernation. It addition

8 *Prairie Farmer.* August 12, 1865.
9 Insects Injurious to Fruits: 363.

to the above facts, observation in the field showed that there was no tendency to mate during the fall. Hence it is evident that the statement that there is more than one brood each year is wrong. The numerous beetles seen in the spring are the same beetles that were seen in the fall, which have hibernated.

Summary.—At the present time, the known facts regarding the life history and habits of the striped cucumber beetle, combined with what is known of closely related species of beetles, indicate the following cycle: The adult beetles hibernate in the ground below the frost line. In the latitude of Long Island they issue from the ground during May and the first of June, depending somewhat on the weather conditions. They feed ravenously for a few days before they commence to pair. Wherever they chance to be feeding during the latter part of June and during July, there they drop their eggs. The larvæ or grubs require moist earth in which to live; they feed upon the vines and fruit wherever these come in contact with the moist earth. About one month is required by the larvæ to feed and develop, after which they form a small cavity or cell in the ground, and change within this to the pupal or resting stage. The pupal stage lasts from one to two weeks, when the adult beetles emerge. The new brood of beetles commences to appear about the middle of September. At this time but few of the old beetles are left. This new brood feeds greedily until driven into hibernating quarters by frosts.

DESCRIPTION.

The adult striped cucumber beetle, or "striped bug," as it is wrongly called, is too well known to need any description.

As the eggs have never been described, and as the larval and pupal stages are not so well known, they are given.

Egg.[10]— To the unaided eye the egg, when first deposited, appears to be very light yellow in color; nearly round and but

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10 Shortly after the above description was ready for the printer, I received U. S. Dept. Agr., Div. Ent., Bul. 19, n. ser., in which F. H. Chittenden describes the egg, hence his description has priority.

little larger than the point of an ordinary pin. As seen by the aid of a microscope or good hand lens, it is found to vary in shape from a perfect ellipse to an oval, and is not as pointed as the egg of the corn root worm(*Diabrotica longicornis*), as shown by illustration of the latter as given by Dr. Forbes.[11] They have the same pentagonal markings as have the eggs of the *D. longicornis.* The eggs average 0.69 mm. long and 0.48 mm. wide.

Larva.— The larva, or "grub," would be described by a farmer as a small white wire-worm with a dark brown head and tail; it being hard to tell which end is head and which is tail. In shape, they are nearly cylindrical, about one-thirty-second of an inch wide and varying from one-fourth to five-eighths of an inch in length. With the exception of the head, first segment back of the head and the anal plate, which are dark brown, the body is pure white. The head-end can be distinguished by the fact that the head is only about one-half as wide as the body. The anal plate is as wide as the body, darker colored than the head, in fact, nearly black at the margin. The above are the only characters to be seen without the aid of a hand lens. With the latter, the anal plate will be found to have two minute, upturned teeth on its posterior margin. A few scattering hairs can also be seen. Six small thoracic legs will be found near the head, and one protractile proleg will be found on the ventral side of the anal plate.

Pupa.—During part of the pupal or resting stage, the striped beetle is nearly pure white in color. The peculiar shaped wing pads and folded legs are the most conspicuous part of its body. A few scattering hairs can be seen by the aid of a lens.

PARASITES.

Dipterous.— The dissections show that old beetles, taken during the latter part of July and during August and September, were frequently parasitized with the maggot of a tachinid fly. The eggs

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11 Twelfth Report of State Ent. Ill., 1882: 18.

of this fly are laid on the body of the beetles. After hatching from its egg, the maggot eats its way into the body of the beetle where it proceeds to devour its host from within. The parasites undoubtedly cause the retarded development found in many of the beetles when dissected.

Entomologists who have bred these parasites have always obtained but one species of fly; hence I assume that the maggot found by dissections was that of a fly called *Celatoria diabroticae* Shimer.

Worms.— I am unable to find in any of the entomological writings, mention of the fact that a species of nematode, "Eel-worm," occurs as a parasite within the body of the striped beetle. Several beetles were found to have vast numbers of these parasites within their bodies. Whether this worm found by dissection within the bodies of the beetles is closely related to the trichina that infests swine and causes "measly pork" or is related to the anguillule that infests plants, remains to be proven. As all the material was preserved simply for the dissection of the beetle, none of the worms were obtained in the best condition for microscopic study.

REMEDIES.

Although certain classes of agricultural paper writers have annually, for nearly fifty years, recommended various foul-smelling remedies which are warranted to keep the striped beetle away from cucumbers, squashes and melons, this pest continues to be as injurious as ever and seems to be constantly increasing in numbers. If the remedies which are warranted to keep the beetles away from the vines would do so, even though the beetles are not killed, there ought to be a decrease in their number; since, so far as is known, the beetles breed on no plants except the squash, melon, cucumber and plants closely related to them.

POISONS.

As shown under "Habits," there are only two short periods during which the striped cucumber beetle can be actually killed

by poisoning: First, just previous to the time when the beetles commence to pair, and second, during a short period in September and October. Poisoning during the latter period is effective only on areas where fall-flowering weeds are scarce.

Spraying cucumber and melon vines with Paris green and water has often been recommended. Tests during the past two years show that very few beetles are killed by this method and that the risk of killing the vines is too great to allow the measure to be recommended for general use. Instead, I would recommend the use of the poisoned bait which is given under "Trap crops."

PREVENTIVE MEASURES.

COVERINGS.

One of the oldest methods of keeping the beetles from the small plants is the use of covers. As near as I can determine, this method was first used by Dr. Fitch,[12] who in 1865 claims to have used the method for twenty years previous to the time it was published. According to Dr. Harris[13] the use of covers was published in the *New England Farmer* previous to 1852. The cover recommended by Dr. Fitch was, apparently, a crude affair, while that recommended by Mr. Levi Bartlett in the *New England Farmer,* as quoted by Dr. Harris, was apparently just as handy and simple as those recommended in 1889, forty years later, by Professor Weed.[14]

The styles of covers recommended vary from an ordinary box open at top and bottom, the top being covered with cheese cloth or with millinet, to patented wire covers which are costly. The least expensive forms are the box just mentioned; wire or staves bent in a half circle, the ends stuck into the ground over the vines and then covered with cloth, which is held in place by placing dirt along on the edges; and lastly, a box made from two short boards six inches wide and a rectangular cloth. The two ends of the

12 Tenth Report on Noxious and Other Insects of the State of N. Y.: 440.

13 Insects Injurious to Vegetation: 125. Flint's ed., 1852.)

14 Ohio Agr. Exp. Sta. Bul. 13: 146–147.

cloth are tacked to the edges of the boards; short cleats nailed to the boards are inserted into the ground and hold the boards on edge and the free edges of the cloth are covered with dirt.

During 1898, Mr. John O'Donnell, a market gardener of the Borough of Queens, tried the six-inch wire plate-covers on a large scale as shown in Plate XVIII. These cost two cents apiece when bought by the thousand; the cost per acre for first year being a trifle over $40.00. These covers are provided with a tin margin which is very convenient for forcing them into the soil, thus keeping the beetles from working under them. This style of cover answered very nicely until the plants were up but, like all covers they have the disadvantage of protecting the vines only while coming through the ground. If left over the vines too long, the latter are liable to become drawn and weak. At best there is danger when the covers are removed that a heavy wind will injure the vines to such an extent that they will never recover. Besides, all covers have the disadvantage when used alone, of not only giving the beetles a feeding place, but a breeding place when removed.

TIME OF PLANTING.

Growers who raise cucumbers for pickling purposes practice late planting; planting for this purpose during the last week in June and the first week in July and thus avoiding the ravages of the beetles during their spring feeding period. During the past few years, the ravages of the cucumber mildew on the late crop has made it desirable, on the part of pickle growers, to plant earlier. Furthermore, in preparing a grade of pickles known as "dills" an early pickle is preferred. Mr. Chittenden[15] states than in some sections planting in frames and hot houses, and transplanting to the field is advisable. By planting in the field as early as possible, and following the directions given under the head of "Trap-crops," the use of covers for melons and cucumbers can usually be avoided.

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[15] U. S. Dept. Agr., Div. Ent., Circ. No. 31, 2d ser.

TRAP CROPS.

(1) *Beans.*— The bean has often been recommended as a food plant to be used to keep the beetles from cucumbers. In sections of the country where golden rod is not plentiful during the fall, the planting of beans in and along the margins of cucumber and melon fields about September 1 ought to make a good crop upon which to poison the new brood of beetles. As soon as the beetles are noticed feeding upon the bean vines, the latter should be thoroughly dusted with green arsenite (copper arsenite[16]) or even Paris green. Although not tested, I doubt if beans would be a good trap crop to use in the spring unless they were younger and more tender than the vines of the crops being protected. If the beetles cared more for beans than for cucumbers they would be found in the bean fields instead of in the cucumber fields during the spring. Possibly beans could be used in small gardens as a spring trap-crop in connection with covers.

(2) *Squashes.*—In 1898, a series of tests on the use of squashes as a trap-crop the details of which are given under the head of "Field notes," were carried out on an extensive scale in the pickle section of Long Island. The results show that, by planting squashes around the margin of the field where cucumbers or melons are to be planted, the beetles will not disturb the cucumbers, and, if several plantings of the squashes are made and allowed to remain on the field, the beetles will disturb the cucumber vines but little during the whole season. We do not recommend the planting of squashes simply to feed and grow the beetles upon, on condition that they will not disturb the cucumbers, but do recommend their use with other measures as followed in the field tests. Squashes, if used rightly, answer the purpose for which covers are used. The beetles feed on them and thus allow the cucumber and melon vines to make their early growth undisturbed so that they can better withstand later attacks. Further-

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[16] Lead arsenite is also colored and sold under the incorrect name, green arsenite.

Plate XVIII.—Use of Plate-Covers to Protect Young Plants.
Photographed June 15, '98.

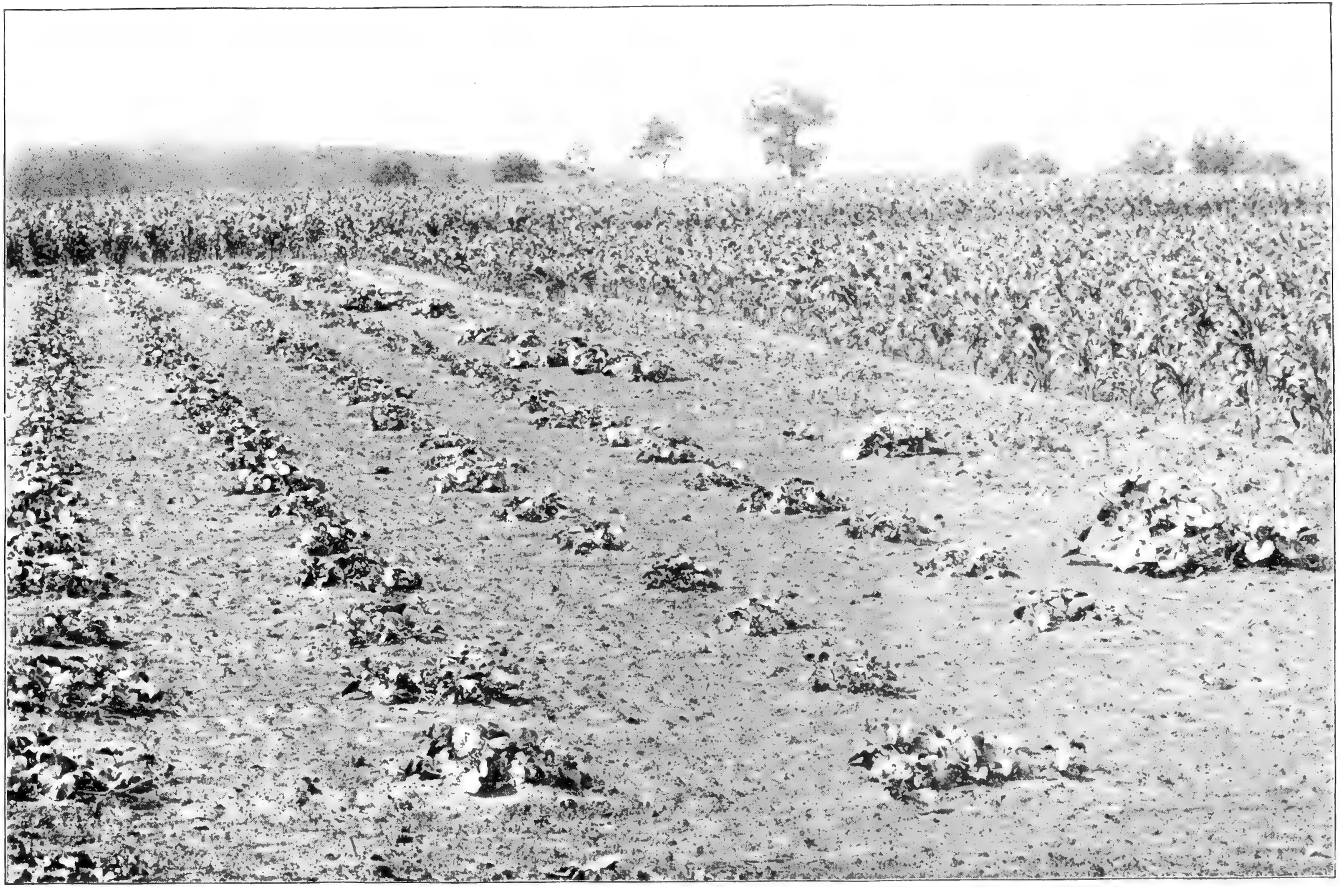

PLATE XIX.—CUCUMBER FIELD WITH SQUASHES ON BORDER.
Photographed June 19, '98.

more, there are a few days during which the beetles can be poisoned on the squashes; hence they are a valuable adjunct even where covers are used.

None of the measures recommended thus far are as valuable when used alone as when several are combined together as was done in the field tests. Possibly the use of Bordeaux mixture and squashes would not be as economical in small gardens as would the use of covers and squashes. For growers of pickles and those who grow cucumbers for market, I would recommend the use of Bordeaux mixture on the cucumber vines and the use of squashes both as a poisoned bait and as a lure. Several rows of squashes should be planted around the margins of the field about four days previous to planting the field with cucumbers or melons, as the case may be. If desired, the squashes can be put in drills a few feet apart, or even sown broadcast. At time of planting the cucumbers, make a second planting of squashes on the margins of the field. If the beetles are very thick, a third planting of squashes had better be made. As soon as the first beetles are seen around the squashes, about one-half of the latter, especially the outside rows, should be thoroughly dusted with green arsenite or any other form of arsenic that can be most easily obtained. Part of the squash plants should be left untreated, for the reason that a rain or heavy dew may follow the application of the poison and kill the treated plants before many beetles are killed. When the cucumbers are fairly up, they should be sprayed with Bordeaux mixture, using four pounds of copper sulphate and four pounds of quick lime to forty-four gallons of water, or what is usually designated as the 1-to-11 formula, for making the mixture. This mixture can be applied most cheaply, while the vines are small, with a knapsack spraying machine. At the time the cucumbers are sprayed, more of the squashes can be dusted with the copper arsenite. If possible, the arsenite should be blown onto all parts of the squash plant, the object being to allow the beetles not a particle of food that is not poisoned. After the beetles commence to pair, the squashes can be cultivated out, although it is well to

leave a few of the plants for the beetles to work upon, especially during the period while the first fruit is setting on the cucumbers; the reason for this being that the beetles prefer the flowers of the squash to those of the cucumber.

Although not absolutely necessary, I would recommend that the cucumbers be sprayed at least three times with Bordeaux mixture; the first spraying being made as soon as the seed leaves are exposed, the second, when the third true leaf is exhibited and the last, just before the plants commence to vine. Each grower must use his own judgment as to the time of these applications. If the vines have an early start, and the beetles appear on the field late in the season, the spraying will have to be carried along later. The cost of three applications of the Bordeaux mixture will not exceed $2.00 per acre; whereas the cost of wire covers would be $40.00 per acre and probably they will not last over three years. The treatment with Bordeaux mixture not only makes the vines distasteful to the striped cucumber beetle and to the flea beetle, but also protects the vines from anthracnose and various other diseases to which they are subject. Finally, I would recommend the use of Bordeaux mixture in small gardens after the covers are removed.

Those who cannot afford spraying outfits can use air-slaked lime in connection with covers and squashes, as this will make the cucumber vines unpalatable to the beetles, but it must be remembered that lime is liable to stunt the plants.

In conclusion, it must be borne in mind, that neither Bordeaux mixture nor air-slaked lime will give absolute protection to the vines if the beetles can find no other food plants which they prefer to feed upon.

REPELLANTS AND DRIVERS.

Other remedies in large number have been recommended. Some of them give partial relief, but in most cases their success depends upon the habit of the beetles of being easily frightened away from the plants, especially after they have commenced to

paid. A few of the remedies are distasteful to the beetles, but the difficulty of applying them to all parts of the plants, makes their use only a partial success. When the beetles are frightened from the plants they usually return in a short time. They may not appear to be as numerous, but they will be found scattered over the entire field and hidden in the loose dirt, gnawing off the stems below the surface of the ground. Even the best of these remedies, applied when the beetles first make their appearance, will be found nearly worthless if tested alone; in fact, there are times, except where a trap-crop is used, when nothing but a good wire cover will prevent their damaging the vines. I have even seen them gnaw holes in cloth covers to get at the plants. At such times they should have all the poisoned squash plants they will eat.

(1) *Bordeaux mixture.*[17]— One of the best remedies for making the vines distasteful to the cucumber beetle is Bordeaux mix-

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17 During the past few years entomologists and mycologists have been recommending the use of Paris green with Bordeaux mixture for various insect, for the following reasons: There is less danger of injury to the foliage from the Paris green; the Bordeaux mixture helps to retain the poison on the foliage longer than Paris green alone would adhere; and, lastly, the application of a fungicide and an insecticide at one and the same time is a saving worth looking after.

Observations and tests on potato and cucumber beetles convince me that if we desire to kill these pests, the Paris green must be used alone, before the Bordeaux mixture is applied.

In 1896, several tests were made on the Colorado potato beetles, to determine effects of Bordeaux mixture as an insecticide. To be sure in each case that every part of the potato plant was thoroughly covered, they were dipped in the Bordeaux mixture, after which they were placed in a breeding cage and a large number of young potato beetles placed on them. Although the plants were kept fresh, not one of the beetles would feed upon them, and all finally starved to death. This test was repeated three times with the same result in each case. The question arises, why not use the Bordeaux mixture as an insecticide? The difficulty is that in the field it is impossible to get the mixture onto all parts of the plants, the result being that potato and cucumber beetles can find places to feed without touching the Bordeaux mixture. Hence, it is seen that when Paris green is used with Bordeaux mixture to kill the above leaf-eating beetles, the value of the Paris green is destroyed. If we wish to kill these pests, the Paris green must be applied alone.

ture. This not only makes the vines offensive, but the application of it drives the beetles away from them. Its use gave just as good results as air-slaked lime; besides it had the advantage, when employed at the rate of four pounds of copper sulphate to forty-four gallons of water, of not injuring or stunting the vines in the least. Furthermore, it can be more uniformly applied to all parts of the vines and it adheres better than air-slaked lime.

(2) *Air-slaked lime.*— Dusting the plants with air-slaked lime has long been recommended and often proves quite successful for driving the beetles from the vines as well as being distasteful to them. But, in order to prove successful, the beetles must not occur in large numbers; must have passed their first feeding period and commenced to pair, or other food plants must be plentiful. Tests during two years convince me that generally the use of air-slaked lime, without a bait crop, causes the beetles to work down next to the root and gnaw at the stems below the surface. It is also liable to be too caustic and stunt the vines. Some have recommended the use of Paris green with air-slaked lime. Tests of this have resulted the same as in the use of Paris green with Bordeaux mixture, viz.: no beetles could be induced to feed upon the parts of the plants protected with the lime and Paris green.

(3) *Other remedies.*— The following mixtures and remedies have been tested along with air-slaked lime: Kerosene mixed with air-slaked lime, turpentine mixed with air-slaked lime, kerosene mixed with land plaster, turpentine mixed with land plaster, rags and corn cobs dipped in kerosene and placed near the plants, and tobacco dust.

The first four gave no better results than air-slaked lime used alone. Land plaster had the advantage of not stunting the vines. Kerosene used on rags and corn cobs, which is said to smell so bad that the beetles will not stay in the same field, was of no value whatever. Tobacco dusted on the leaves and placed around the base of the plants to the depth of one-fourth inch was of no value

in keeping the beetles away. When plants were examined, the day following the treatment, the beetles were found feeding on the plants, and when disturbed, they hid themselves in the tobacco dust at the base of the plants. (These were Long Island "cuck" beetles.) Possibly a good quality of snuff would be more effective than tobacco dust, but it would be an expensive remedy.

Road-dust, ashes, soot, charcoal, salpetre, cow-manure, hen-manure, burdock infusion, slug shot and "bug death" are a few of the numerous measures often recommended which have no value except to frighten the beetles away from the plants at the time they are applied.

CONCLUSION.

From what has been given regarding the habits of the striped beetle, and the results of tests of different remedies, it will be seen that no one measure will give absolute protection to the vines of cucumber and melon. Furthermore, it will be seen that if Paris green, green arsenite or in fact any of the arsenites are used with Bordeaux mixture or with air-slaked lime, with the expectation of killing the beetles, they will be failures. Hence, I recommend the use of squashes as a lure and as a poisoned bait, combined with the use of Bordeaux mixture on the cucumber vines, and in some cases, also combined with the use of covers. I also recommend the planting of squashes or beans in September for the purpose of poisoning as many of the beetles as possible during the fall. Green arsenite and Paris green can be, and frequently are, used with water for poisoning the squashes and beans, but as the object of the latter is to kill as many of the beetles, in as short a time as possible, it is better to use the arsenites dry, for the simple reason that they can be applied stronger and not kill the vines as quickly as when used with water.

FIELD TESTS AND NOTES.

WORK OF 1897.

Plan of test.— The field work of 1897 was carried out on a small garden patch of cucumbers and muskmelons at Floral Park. The vines were planted in drills and thinned after commencing to run. Seven rows of cucumbers were treated as follows, each row being divided into four equal parts:

TREATMENTS USED IN COMBATING STRIPED CUCUMBER BEETLE ON CUCUMBERS.

Row 1..	Bordeaux mixture and Paris green.	Bordeaux mixture and laurel green.	Paris green in water.	Paris green in water.
Row 2..	Resin-lime mixture and Paris green.	Resin-lime mixture and laurel green.	Laurel green in water.	Laurel green in water.
Row 3..	Check.	Check.	Check.	Check.
Row 4..	Tobacco dust.	Air-slaked lime.	Air-slaked lime and turpentine.	Air-slaked lime and kerosene.
Row 5..	Kerosene on rag.	Kerosene on corn cobs.	Plaster and turpentine.	Plaster and kerosene.
Row 6..	V shaped wire covers.	V shaped wire covers.	Dry Paris green.	Dry Paris green.
Row 7..	Cloth covers.	Cloth covers.	Dry laurel green.	Dry laurel green.

The same number of rows of muskmelon were treated in same manner. These measures were started May 25, that is, we did not wait for the beetles to appear before making the first treatment. With the exception of the covers the treatments were repeated as follows: June 1, 11, 14, 23, and July 6. Where Paris green was used in water or dry, the vines were replanted whenever killed.

A summary of the notes shows that none of the above measures except the covers kept all the beetles away and in a few cases the beetles worked through and under the covers. As soon as a cover was removed, the beetles would attack the plants, and where the covers were left over until the vines were ready to run, the plants were twisted and injured by the wind after the covers were removed, so that the plants were worthless.

During the first ten days a few dead beetles were found around the plants treated with dry Paris green.

In all other places where Paris green was used, also in all cases where the laurel green was employed, no dead beetles were found.

In every case where air-slaked lime was used, the plants were stunted.

Of all mixtures and combinations of mixtures the Bordeaux mixture gave the best results. The resin-lime mixture answered as well as the Bordeaux mixture simply because it contained lime.

Kerosene and turpentine used with air-slaked lime or with land plaster gave no better results than air-slaked lime used alone.

Where all the above substances were used, the beetles worked on the under side of the leaves and gnawed the stems below the surface of the ground or wherever they could find a spot not covered with an unpalatable substance. Rags and cobs soaked in kerosene were absolutely worthless; none of the vines were saved by these substances. The same was true of tobacco dust. In fact, the beetles would feed on the leaves that were dusted with tobacco and if disturbed would hide in it, where piled around the base of the vines.

WORK OF 1898.

The tests of 1898 consisted: First, in the use of Bordeaux mixture on the vines we wished to protect; and second, the use of green arsenite dusted on a trap crop of squashes for poisoning the beetles. The tests were made in three distinct localities. One field, consisting of one-third acre of muskmelons, was located at Floral Park, N. Y., on the grounds of John Lewis Childs. Another field, containing two acres of cucumbers, was located at Hicksville, N. Y., on the grounds adjoining the factory of the H. J. Heinz Co., under the management of Mr. Merritt Horner. The third field, containing one acre of cucumbers, was located at Smithtown Branch on the farm of Geo. W. Hallock and Son.

In addition to the above, a test of six-inch wire plate-covers was made on the farm of Mr. John O'Donnell at Jamaica, N. Y. This was an individual test and not under the direction of the Station. We were allowed to note results, but no record of yield was kept.

Plan of tests.— The original plan was to have single rows of squashes planted on the margins of each field before the cucumbers and melons were planted. In addition, arrangements were made for making later plantings between the rows of cucumbers and melons, the distance between being varied. In some cases, cross rows of squashes were planted between every third and fourth row of cucumbers, between every sixth and seventh row, between every ninth and tenth row, between every twelfth and thirteenth row, between every eighteenth and nineteenth row, and between every twenty-fourth and twenty-fifth row.

Preparation.— The first planting of squashes was made as follows: At Floral Park, N. Y., May 18; at Smithtown Branch, N. Y., May 24; and at Hicksville, N. Y., on June 1.

The muskmelons were planted on May 31 and the first cross-rows of squashes planted on same date. The cucumbers were planted at Smithtown Branch on May 31; and the first cross rows of squashes on same date. At Hicksville, N. Y., one acre of cu-

cumbers was planted on June 6, while the second acre of cucumbers was not planted until June 7, and the second planting of squashes was made at same date.

The third planting of squashes was made as follows: At Floral Park, June 14; at Smithtown Branch, June 14; and at Hicksville, N. Y., on June 15.

Treatment.— Cucumbers at Hicksville, N. Y., were sprayed with Bordeaux mixture as follows: June 13, 20 and 29. As there was a bare possibility of killing an occasional beetle, green arsenite was added to the Bordeaux mixture at the first spraying.

June 11, marginal squashes at south end of field where beetles had commenced work were dusted with green arsenite.

June 13, the remaining marginal squashes were treated as follows: One-fourth dusted with green arsenite, one-fourth dusted with lead arsenite, one fourth sprayed with green arsenite in water, one-fourth sprayed with lead arsenite in water. June 24 the first cross rows dusted with green arsenite and lead arsenite; June 29 last planting of cross rows dusted with green arsenite and lead arsenite.

At Floral Park the muskmelons were sprayed with Bordeaux mixture on June 14 and 21 and July 1, green arsenite being used with the mixture at the first spraying.

June 14, the marginal squashes were treated as follows: One-fourth dusted with green arsenite, one-fourth dusted with lead arsenite, one-fourth sprayed with green arsenite and water, one-fourth sprayed with lead arsenite and water; June 21, dusted first cross rows of squashes with green arsenite and lead arsenite.

At Smithtown Branch the field of cucumber vines was sprayed with Bordeaux mixture on June 29 and July 20 and 28. Very few beetles occurred on this field, hence no other treatments were made.

Summary of notes and results.— Melon vines at Floral Park sprayed with Bordeaux mixture (1-to-8 formula) were injured not only the first time when green arsenite was added, but also at the second spraying when the latter was not used.

Green arsenite and lead arsenite, used in water, at the rate of one-half pound to 48 gallons, killed the squash vines sooner than where applied dry. Very few dead beetles were found around the plants sprayed with arsenites in water, while plenty were found dead around plants dusted with green arsenite. Lead arsenite, used dry, did not kill the vines as soon as did the dry green arsenite, but no dead beetles were found where the former was used.

The cucumber beetles did not find the vines at Floral Park until June 14. Though they were quite numerous after this date, not a solitary hill of muskmelons was lost by their work. Enough squashes were kept growing on the margins of the field to furnish them with all the food they required. Plate XIX shows one side of this field taken July 19, with squash plants on margin.

In no case could I find the larvæ working at the base of any of the melon plants, but by the middle of August they were quite plentiful on the underside of the fruits.

By the middle of October the beetles were so numerous that they destroyed all the late set fruits.

The cucumbers at Hicksville were injured by Bordeaux mixture used (1-to-8 formula). Later sprayings (1-to-10 and 1-to-11 formulas) did no harm.

Large numbers of the striped beetles were killed where the first application of green arsenite was made June 11. A few dead beetles were found around squashes dusted with green arsenite June 16, but none were to be found around plants which were dusted with lead arsenite, or even where both arsenites were used in water. Squash plants sprayed with copper and lead arsenites, at the rate of one-fourth pound to 48 gallons of water, were only slightly injured, while in cases where both substances were used dry, the plants were killed.

I never saw such myriads of the striped cucumber beetle as occurred on this field. On the acre of cucumbers planted June 3 nearly every hill was saved, while on that planted June 7 about one-half of the acre had to be replanted three times in order to get a stand. Two factors combined to produce the failure to get

a stand on this late planted acre. First, we had planted only about one-tenth as many marginal squashes at the first planting as was necessary to supply the large number of beetles with food; and, second, at time of first spraying with Bordeaux mixture the late planted cucumbers were just coming up. The result was they could not be thoroughly sprayed, and, as soon as the beetles had devoured the marginal squashes, they went after the cucumbers, even before they were up. It was interesting to note the instinct shown by the beetles in finding the cross rows of squashes as soon as they came up.

Picking on this field was commenced July 30 and continued until September 10. In all 143,455 marketable pickles were obtained from the two acres. These sold for $183.68. The yield per acre was 71,727 pickles and the value per acre $91.84.

At Smithtown Branch but few beetles appeared on the field. These came late in June and fed entirely upon the marginal squashes. The result was a perfect stand of cucumbers. The vines were injured slightly by the first spraying, the 1-to-8 formula being used.

Picking on this acre was commenced July 19 and continued until September 3. A yield of 90,536 marketable pickles, valued at $113.16, was obtained. In addition, 400 ripe cucumbers were sold; about 1,000 ripe cucumbers and 7,000 nubs, actual count, were left on the field; making a total yield of 98,936.

Conclusion.— The results of these tests show three things: First, that if the 1-to-8 formula for Bordeaux mixture is used young cucumber and muskmelon vines will be injured; that it will make the plants unpalatable and drive the beetles as well as any other substance recommended for the latter purpose; and that it is much cheaper than covers. Second, that if green arsenite is used dry on squash vines before the beetles commence to mate, many of the beetles will be killed; also that neither the green arsenite nor the lead arsenite are very valuable if used in water. Third, that a combination of measures must be used, and, that

the beetles must be attacked at the proper season in order to be successful in combating them.

On the supposition that two fields, which were equally well cared for and from which pickles were picked approximately the same number of days, would produce approximately the same number of pickles, some idea of the damage this pest can do to a crop can be obtained by comparing the yield at Smithtown Branch, 90,536 per acre, where, comparatively speaking no beetles occurred, with the yield at Hicksville, 71,727 per acre, where it was a struggle to save the vines. The difference in yield per acre in the two places was 18,809. At least one-half of this difference should be credited to the work of the beetles. If no effort had been made to prevent their work at the latter place, the late planted acre would have been a total failure.

SEXUAL DEVELOPMENT OF THE CUCUMBER BEETLE.

The data given in the following tables are taken from microscopic dissections of material collected during 1898.

SEXUAL DEVELOPMENT OF FEMALE CUCUMBER BEETLE.

I. Specimens taken at Floral Park, N. Y., June 22. Eight females, nine males.

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Medium large	Developed	Numerous, half grown		Slightly enlarged.
No. 2	Medium large	Developed	Numerous, one-third grown.		A straight sack.
No. 3	Small	Developed	Numerous, small		A straight sack.
No. 4	Large	Not developed	None		Large.
No. 5	Small	Partially developed.	Very small		A straight sack.
No. 6	Small	Partially developed.	Very small		A straight sack.
No. 7	Small	Partially developed.	Few small		A straight sack.
No. 8	Small	Partially developed.	Few small		A straight sack.

NOTES.— A few pairing specimens were collected on this date. No. 4 was parasitized with nematodes — probably anguillules.

II. Taken at Hicksville, N. Y., June 24. Thirteen females and sixteen males.

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Small	Partially developed	Numerous, small		A straight tube.
No. 2	Medium large	Developed	Numerous, one-half grown.		Slightly enlarged.
No. 3	Medium large	Partially developed	Numerous, half developed.		Enlarged.
No. 4	Medium large	Developed	Numerous, two-thirds developed		Large.
No. 5	Medium large	Developed	Numerous, two-thirds developed		Large.
No. 6	Small	Partially developed	Not developed		A straight tube.
No. 7	Small	Partially developed	Numerous, small		A straight tube.
No. 8	Medium large	Developed	Numerous, nearly grown		Slightly enlarged.
No. 9	Small	Not developed	None		A straight tube.
No. 10	Small	Partially developed	Few small		A straight tube.
No. 11	Small	Partially developed	Few small		A straight tube.
No. 12	Medium large	Developed	Numerous, nearly grown		Enlarged.
No. 13	Large	Developed	Numerous, full grown	Few	Large.

NOTE.— A few specimens pairing when collected.

III. Collected at Hicksville, N. Y., July 6. Fourteen females, twenty-nine males dissected.

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Large	Developed		Numerous.	Large.
No. 2	Small	Partially developed	Numerous, small		A straight tube.
No. 3	Medium large	Partially developed	Small		Medium large.
No. 4	Medium large	Developed	Small		A straight tube.
No. 5	Large	Developed	Full grown	Few	Abnormally large.
No. 6	Large	Developed		Numerous.	Large.
No. 7	Medium large	Developed	Numerous, half-grown.		Medium large.
No. 8	Medium large	Developed	Numerous, small		Large.
No. 9	Large	Developed			Very small.
No. 10	Large	Developed	Full grown	Few	Medium size.
No. 11	Small	Partially developed	Numerous, small		Small.

NOTES.— Three specimens of females showed no reproductive organs, but the colon in each was enlarged. No. 4, ovaries developed on one side only. No. 9, apparently had been parasitized.

IV. Collected at Floral Park, N. Y., July 6. Six females and four males dissected.

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Medium size	Developed	Numerous, small		Small.
No. 2	Medium large	Developed	Numerous, half-grown		Medium large.
No. 3	Medium large	Developed	Two-thirds grown		Medium large.
No. 4	Medium size	Developed	Small		Large.
No. 5	Small	Not developed			Small.
No. 6	Large	Not developed	Few small		Medium large.

NOTES.— No. 3, ovary developed on one side only. No. 5 apparently parasitized. No. 6 parasitized with nematodes, probably anguillules.

V. Collected at Floral Park, N. Y., July 11. Four females and fourteen males dissected.

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Large	Developed	Numerous, full-grown	Few	Abnormally developed.
No. 2	Large	Developed		Numerous.	Small.
No. 3	Large	Developed		Few	Large.
No. 4	Large	Developed		Few	Very large.

NOTES.—No. 2 had intestine much enlarged. Nos. 3 and 4 were parasitized with tachinids. No. 4 had an ovary on one side only.

VI. Collected at Floral Park, N. Y., July 16. Three females and four males dissected.

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Shrunken	Small			Small.
No. 2	Large	Developed	Few full grown	Few	Medium large.
No. 3	Large	Developed		Numerous.	Medium large.

NOTE.—No. 1 had apparently been parasitized.

VII. Collected at Floral Park, N. Y., July 21. Five females and five males dissected.

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Shrunken	Small	Few		Medium large.
No. 2	Medium large	Developed	Few		Medium large.
No. 3	Medium large	Shrunken			Small.
No. 4	Large	Developed	Few	Few	Large.
No. 5	Large	Developed		Numerous.	Large.

NOTE.— No. 3 parasitized with tachinid maggot.

VIII. Collected at Floral Park, N. Y., July 30. Three females and six males dissected.

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Large	Developed	Few not developed		Medium large.
No. 2	Shrunken	Shrunken			Small.
No. 3	Shrunken	Shrunken	Few not developed		Medium large.

NOTE.— No. 1 parasitized with maggot of a tachinid.

IX. Collected at Floral Park, N. Y., August 6. Six females and five males dissected.

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Large	Calloused in appearance	Few small		Large.
No. 2	Medium large	Calloused in appearance	Few small		Medium large.
No. 3	Large	Calloused in appearance	Few small		Abnormally large
No. 4	Medium large	Developed	Small, numerous		Small.
No. 5	Small		Few small		Very small.
No. 6	Large	Developed	Few small		Very small.

NOTES.— No. 4 apparently checked in development. No. 6 parasitized with maggot of a tachinid, as also was one male.

X. Collected at Floral Park, N. Y., August 9. Four females and five males dissected.

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Medium large	Shrunken	Few small		Large.
No. 2	Medium large	Shrunken	Few shrunken		Medium large.
No. 3	Medium large	Shrunken	Few shrunken		Medium large.
No. 4	Small	Shrunken			Small.

NOTE.— One male parasitized with maggot of a tachinid.

XI. Collected at Floral Park, N. Y., August 22. *Three females and three males dissected.*

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Large	Shrunken	Few shrunken	....	Small.
No. 2	Small	Shrunken	....	....	Medium large.
No. 3	Medium large	Shrunken	....	....	Small.

NOTE.— One male and No. 1 parasitized with maggots of a tachinid.

XII. Collected at Floral Park, N. Y., September 14. *Eleven females and fourteen males dissected.*

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Shrunken	Calloused	Few small	....	Large.
No. 2	Large	Developed	Many small	....	Abnormally large.
No. 3	Small	Not developed	....	....	A straight tube.
No. 4	Large	....	....	....	Shrunken.
No. 5	Shrunken	Calloused	....	....	....
No. 6	Small	Not developed	....	....	A straight tube.
No. 7	Small	Not developed	....	....	A straight tube.
No. 8	Large	Not developed	....	....	A straight tube.
No. 9	Small	Not developed	....	....	A straight tube.
No. 10	Shrunken	Calloused	....	....	Small.
No. 11	Shrunken	Calloused	....	....	Small.

NOTES.— Nos. 1, 2, 4, and 8, and one male parasitized with maggots of a tachinid. Nos. 1 and 2 of males shrunken and organs not distinct.

XIII. Collected at Floral Park, N. Y., September 7. Four females and ***seven*** *males dissected.*

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Large, shrunken	Shrunken	Few small		Small.
No. 2	Large, shrunken	Shrunken	Few small		Small.
No. 3	Large	Shrunken	Few small		Abnormally large.
No. 4	Medium large.	Shrunken	Few small		Large.

NOTE.— Nos. 1 and 3 parasitized with maggot of a tachinid.

XIV. Collected at Floral Park, N. Y., September 23. Two females and ***three*** *males dissected.*

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1	Shrunken	Calloused.			Small.
No. 2	Medium large				Very small.

NOTE.— No. 2 and all three males parasitized with maggots of a tachinid.

XV. Collected at Floral Park, N. Y., October 3. Three females and five males dissected.

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1.	Shrunken	....	......	......	....
No. 2.	Shrunken	....	......	......	....
No. 3.	Small	Not developed.	......	......	A straight pouch.

NOTE.— None of the organs distinguishable in Nos. 1 and 2. Possibly had been parasitized. Three of the males very much shrunken and organs not recognizable.

XVI. Collected at Floral Park, N. Y., October 14. Fourteen females and twenty males dissected.

Females.	Abdomen.	Ovaries.	Ovules.	Eggs.	Copulatory pouch.
No. 1.	Medium size..	Not developed.	......	......	A straight tube.
No. 2.	Medium size..	Not developed.	......	......	A straight tube.
No. 3.	Small	Not developed.	......	......	Very small.
No. 4.	Medium size..	Not developed.	......	......	Very small.
No. 5.	Medium size..	Not developed.	......	......	A straight tube or pouch.
No. 6.	Shrunken	....	......	......	Small.
No. 7.	Shrunken	....	......	......	Small.
No. 8.	Small	Not developed.	......	......	A straight tube.
No. 9.	Small	Not developed.	......	......	A straight tube.
No. 10.	Small	Not developed.	......	......	A straight tube.
No. 11.	Small	Not developed.	......	......	A straight tube.
No. 12.	Small	Not developed.	......	......	A straight tube.
No. 13.	Small	Not developed.	......	......	A straight tube.
No. 14.	Small	Not developed.	......	......	A straight tube.

NOTES.— Nos. 3 and 4 parasitized with maggot of a tachinid; no parasite found in No. 6. The remaining females contained more or less fat or adipose tissue, depending on size. Ten of the males were large and contained a large amount of adipose tissue. The remainder all contained some adipose tissue.

NOTES ON DISSECTION.

In the preceding table the term ovule is used for the eggs until the latter is developed far enough to have a shell or covering formed, after which it is called an egg.

The term copulatory pouch is used for *receptaculum seminis.*

All material was preserved in 2 per ct. formaldehyde. In collecting the beetles for preservation no effort was made to capture more males than females. Those collected during June and July were taken wherever the beetles were congregated on leaves to feed and pair; with the exception of those taken Oct. 3 and 14, those taken after July were collected in flowers of squashes; those taken on Oct. 3 and 14 were collected on the fruits of the musk-melon.

Indirectly the dissections show the excess of males over the females at each period of collecting, but this does not prove that the males exceed the females in number, as there is a possibility that the females secrete themselves while depositing their eggs.

In all about three hundred dissections were made in which the males exceeded the females in the proportion of 3:2.

THE FOREST TENT-CATERPILLAR.*

V. H. Lowe.

SUMMARY.

The forest tent-caterpillar has been unusually destructive during the past season, its ravages extending over a wide area. The caterpillars feed upon the foliage of a large variety of forest, shade, and fruit trees, but during the past season have been especially destructive to sugar maples.

The life history of the insect is similar to that of the apple-tree tent-caterpillar, discussed in Bulletin 152 of this Station, except that the forest tent-caterpillars do not build conspicuous nests.

The insect may be successfully combated in all of its stages, but under most circumstances, is especially susceptible in the caterpillar stage.

INTRODUCTION.

Probably the most important entomological event in this State during the past season was the unusual outbreak of forest tent-caterpillars in Central, Eastern and Northern New York. While this insect is not a newcomer in the forests and orchards of this State, there are no records indicating that it has ever before occurred in such great numbers over so wide an area. Although the caterpillars were unusually numerous in certain sections of the State, the distribution of the species within our borders is not limited to these sections. On the contrary it is found over almost the entire State and in sufficient numbers to make it of much economic importance.

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* **Reprint of Bulletin No. 159.**

The forest tent-caterpillar differs from most species usually discussed in our bulletins in that it is of importance not to the farmer alone, whose fruit and forest trees it readily defoliates, but to the people of the villages and cities as well, when, as during the past season, the hordes of caterpillars defoliate and render unsightly the maple and other shade trees of many village and city streets.

This extensive destruction has created a general interest in the species so that there is a demand from all classes of people for information on the subject. The writer has had the species under observation during most of the past two seasons and has prepared this bulletin with the hope of aiding in disseminating the desired information.

THE FOREST TENT-CATERPILLAR.

Clisiocampa disstria Hubn.

Order LEPIDOPTERA. Family LASIOCAMPIDAE.

CLASSIFICATION AND NAME.

Classification.—As indicated by its scientific name the forest tent-caterpillar belongs to the same genus, and hence to the same order and family as the apple-tree tent-caterpillar discussed in Bulletin 152 of this Station. The two species are closely related and have many similar habits.

Scientific name.— The species was originally described by Hubner,[1] probably in 1822, as *Malacosoma disstria,* but was later referred to the genus *Clisiocampa* established by Curtis in 1828.

Popular name.—The popular name "Forest Tent-Caterpillar" or as occasionally given "The Tent-Caterpillar of the Forest" is in reality a misnomer for the caterpillars seldom spin a true tent, although they have the habit of leaving a thread of silk wherever they go. It has also been referred to by some writers as the "Forest Caterpillar."

1 Verzeichniss bekannter Schmetterlinge, p. 122.

HISTORICAL ACCOUNT.

The forest tent-caterpillar is considered a native of Eastern North America. We do not know how long it has been depredating the forests, but its ravages have been noted for more than a hundred years. One of the first authentic references[2] to it was in 1797 with which account probably the first figures of the caterpillar and cocoon are given. That the insect was then known to be a very destructive one is indicated by the statement of Mr. Abbott that it "is sometimes so plentiful in Virginia as to strip the oak trees bare." As a natural result of the settlement of the country, the clearing of the land and the planting of orchards, the depredations of the caterpillars gradually became more noticeable. It is not probable, however, that it was considered a very serious pest in the orchard until 1841, when Harris[3] mentioned it briefly. In 1844 the same writer discussed[4] it more at length, referring to it as "a new depredator of the orchard" as if he considered the habit of feeding upon the foliage of fruit trees a newly acquired one. Like most other insects this species undoubtedly had its periods of abundance and decline, but of this there is little positive evidence in the early references to it. Harris[5] again mentioned it in 1852 as an apple pest, as did Fitch[6] in 1856 and 1858. There appears to be no further indication of extensive injury until 1866 and 1867, when the caterpillars again became very abundant, especially in western New York. Since then there have been frequent accounts of their ravages all along the Atlantic States, the outbreaks usually being confined to quite limited areas. Some of the most important of these were in Maine in 1863, 1867, 1874, 1875 and in 1889; also in South Carolina in 1891 when the caterpillars appeared upon the forest trees in almost incredible numbers. During the past three or four years

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2 Smith and Abbott. Insects of Georgia, p. 117.

3 Harris. Insects Injurious to Vegetation. 1st ed., p. 271.

4 New England Farmer, 5: 412.

5 Harris. Insects Injurious to Vegetation. 2d ed., p. 291.

6 Fitch. Second and Fifth Reports on the Insects of New York.

there has been a notable increase in the number of caterpillars in New York and throughout the New England States.

But little was written about the history of this insect in the west previous to 1870, when Dr. C. V. Riley[7] mentions its ravages during the previous two years in Arkansas, and also states that "in many parts of Missouri it has been very destructive during the past two summers." From the statements of Riley, Bruner, Murtfeldt and Lugger it appears that the caterpillars have caused a similar and probably equal injury from time to time in the middle states. The extent of its distribution in the west is not definitely known, but it probably occurs sparingly as far west as California.

History in New York State.—Among the first to write about the ravages of the forest tent-caterpillar in this State was Dr. Asa Fitch, our first State Entomologist. There are no indications in his writings that the insect was considered of especial economic importance in this State during the first half of the present century. He refers to it but twice in his fourteen reports. The first reference[8] was in 1856 in which he states that "here at the north this insect is far less common than the other species" (the apple-tree tent-caterpillar, *C. americana*). In this report and later[9] he considers it a serious pest to the oak, but otherwise of no especial economic importance.

One of the earliest outbreaks in the State of which there is a record was in Western New York in 1866 and 1867 when the caterpillars occurred in great numbers upon the foliage of both forest and fruit trees. In 1886 Dr. J. A. Lintner,[10] second State Entomologist of this State, referred to their serious depredations in apple orchards in some sections of the State. During the past ten years this insect has attracted much more attention than at any

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7 American Entomologist and Botanist, 2: 245; 261–266.

8 Fitch. Second Report on the Insects of New York. 1856, pp. 198, 199.

9 Fitch. Fifth Report on the Insects of New York. 1859, pp. 820, 822.

10 Lintner, J. A. Third Report, pp. 91, 93; New England Homestead, 20: 229.

time previous. Dr. Lintner[11] recorded the appearance of the caterpillars in great numbers in Washington Co., in 1889–90. They were especially destructive to maple trees. Again in 1893 he referred to their ravages in the apple orchards in certain sections of the State. During 1896 and 1897 the caterpillars were abundant throughout the Central and Northeastern part of the State and during the two following years there were several important outbreaks in some of the timbered sections.

THE RECENT OUTBREAK IN THIS STATE.

Its extent.—Although as previously indicated the forest tent-caterpillar is far from being a newcomer in the State we are unable to find any records which indicate that it has ever before occurred in such great numbers over so wide an area within our borders. To ascertain approximately the extent of the outbreak, letters of inquiry were sent to correspondents in nearly every county in the State. From the data thus secured, together with personal observations in some of the most seriously infested sections of the State, the accompanying map has been prepared (Plate XX). This map is intended to show only approximtaely the area that was most seriously infested. It is not improbable, however, that the caterpillars occurred scatteringly throughout the entire State as they were seen in more or less abundance from Long Island to Buffalo and along the most Northern boundaries of the State. The outbreak was most severe along the Western, Northern and Eastern slopes of the Adirondacks, the valley of the upper Hudson, the Mohawk valley, the Catskill region, in the southern part of Onondaga and Madison, and throughout Cortland, Chenango and Otsego counties, and in the Upper Genesee valley.

Special reports from infested localities.— During the season reports were received from correspondents in localities where the caterpillars were abundant. These reports together with similar facts gained by personal observation are of value principally

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11 Lintner, J. A. Sixth Report, p. 106.

because they furnish information as to the exact distribution of the species. The following are the localities, the name of the nearest postoffice being given: Clinton County — Ellenburg Depot, and five miles southeast and the adjoining town west; West Chazy and locally throughout the Southern and Western part of the County; Peru and vicinity. Warren County — Putnam, Salem and Glens Falls. Washington County — Our correspondent states that the caterpillars were found throughout the county and names the following postoffices: Cambridge, Greenwich, Granville, Salem, Argyle and Whitehall. Saratoga County — Saratoga Springs, Clifton Park, Elnora Station, Fort Edward and throughout the Southern and Eastern part of the County. Schenectady County — Schenectady, Duanesburg and throughout the county. Albany County —Albany and throughout the County. Rensselaer County — Castleton, Nassau, Brainard, Schodack Depot, East Schodack, East Greenbush and West Sand Lake. Green County — South Cairo, Pine Hill and Prattsville. Dutchess County — Fishkill, comparatively few. Delaware County — Cannonsville and Andes. Rockland County — Suffern, not abundant. Orange County -- Pine Bush, not abundant. Schoharie County — Cobleshill, Hyndsville, Seward, Sharon, Central Bridge, Schoharie, Middleburg, along the Cherry Valley railroad and throughout the County. Montgomery County — Fultonville and Fort Plain. Fulton County — Johnstown and vicinity. Franklin County — Malone and vicinity. St. Lawrence County — Hammond, Chipman, Gouverneur, Constableville, along the valley of the Black River, Russell, Palmerville, DeGrasse, North Russell, Canton, South Canton, Pierrepont and quite generally over the County. Herkimer County — Little Falls, Herkimer, Ilion, West Schuyler, Frankfort and throughout the County. Warren County — Salem, Glens Falls and Cambridge. Oneida County— Utica, Rome, Waterville Caseville and throughout the County. Otsego County — Unadilla and Worcester. Chenango County — Union Valley, Pitcher Springs and vicinity. Cortland County— Cortland, Cincinnatus and Taylor. Steuben County — Hornells-

ville, Howard, Allen, Alfred, Belmont, Belfast, Belvedere, Birdsall, Canaseraga, West Almond, Almond, Wellsville, Independence, Scio, Bath, Fremont and surrounding towns, Cuba and Olean. Monroe County — Rochester, Brighton and vicinity in limited numbers. Wayne County — Lake Side, not abundant. Ontario County — Geneva and in limited numbers throughout the County. Seneca County — Waterloo. Although few definite reports were received from the extreme Western counties, it is not improbable that the caterpillars were to be found scatteringly at least throughout the western part of the State, as the conditions would be very similar to those in the western New York counties where they were observed.

FOOD PLANTS.

The early references to the food-plants of this insect indicate that it was most destructive to maples, oaks and elms. Later observers have recorded a large number of species of trees, shrubs and vines. The most complete list of food-plants is given by Weed.[12] These represent sixteen families as follows: *Rosaceae,* apple, plum, hawthorn, mountain ash, cherry; *Hamamelidaceae,* sweet gum; *Berberidaceae,* barberry; *Cupuliferae,* beech, birch, oak; *Oleaceae,* ash, fringe tree; *Tiliaceae,* linden; *Salicaceae,* poplar, willow; *Sapindaceae,* maple, horsechestnut; *Cornaceae,* sour gum; *Juglandaceae,* hickory, walnut; *Saxifragaceae,* currant; *Caprifoliaceae,* diervilla, honeysuckle; *Urticaceae,* elm; *Leguminosae,* pea, locust; *Magnoliaceae,* magnolia; *Vitaceae,* woodbine.

During the past season the caterpillars have been especially destructive to sugar maples. Next to the maples they seemed to prefer basswood and elm, but in some localities were especially destructive to poplar and oak. At Little Falls, N. Y., the writer observed them feeding upon ironwood (*Ostryia*), family *Cupuliferae,* making a food-plant additional to the above list.

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12 N. H. Agr. Exp. Sta. Bul. 64, pp. 86–87.

DESCRIPTIONS AND LIFE HISTORY.

The egg.— The eggs are laid close together forming bands which encircle the twigs. These bands or masses are abruptly cut off on the edges and in this the egg-masses of this species differ from those of the apple-tree tent-caterpillar which are more distinctly oval in outline. The frothy covering also differs in color, being a dull gray instead of brown. As referred to on a subsequent page there is a noticeable variation in their size this year. Plate XXI, fig. 1, is from a photograph of two egg-masses which differ greatly in size. The upper one has the more typical shape.

The eggs are placed on end side by side with somewhat more regularity than those of the apple-tree tent-caterpillar. According to Riley[13] the female while depositing her eggs "stations herself, for this purpose, in a transverse position across the twig." The egg-laying habits of three females kept by the writer in the laboratory were carefully noted. The actions of these females indicate that there may be exceptions to the habits observed by Dr. Riley; for none of them placed themselves in a transverse position across the twig, but stood lengthwise of it or nearly so, and moved sidewise while depositing the eggs. When one row was finished the next was immediately commenced. The eggs were placed very close together. With each egg an abundance of frothy glue was discharged, completely covering it and hardening almost immediately. The females died within a few hours after completing oviposition.

When first laid the eggs are nearly white but soon became a dull gray. They measure on the average 1.2 mm. in length and .75 mm. in diameter at the upper end, tapering slightly to the lower end. They squarely cut off at the upper end but rounded at the lower. The upper end is also distinctly margined with white, the central area being darker and somewhat depressed. At first this depression is very slight but gradually more pronounced as the embryo caterpillar becomes fully formed.

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13 Amer. Ent. and Bot., 2: 261.

Small size of the egg-masses this year.—The egg-masses are said to contain from 300 to 400 eggs. Riley states[14] that he found the number in five masses ranging from 380–416. Compared with these figures the egg masses this year are very small as indicated by the examination of a large number taken in the vicinity of Geneva and from various sections of the State. They average only half this size, containing, as a rule, but about 200 eggs. Many were much smaller than this. As each female moth probably deposits all of her eggs in one mass this indicates an unusual falling off in the number of eggs deposited.

Time of egg laying and period of incubation.— In the latitude of New York the eggs are laid during the last week in June and first week in July.

The young caterpillars are fully developed within the eggs before the summer is over, but do not escape until the following spring. On August 29, an examination of eggs showed fully developed caterpillars. Unlike the apple-tree tent-caterpillars which were found bent backward in the eggs examined, all of the caterpillars in about 100 eggs opened by the writer were bent forward nearly double so that the head and posterior part of the body came nearly together.

The larva or caterpillar.— The earliest caterpillars probably appear with the first warm days of spring. This season they were found about Geneva during the last week in March. The period of hatching, however, extends over a month or more, as young caterpillars that had not yet passed their first molt were found at Geneva as late as May 26, and colonies of newly hatched caterpillars were found at various times between, while by May 22 large numbers of caterpillars had reached nearly full size.

Growth.— Under normal conditions the caterpillars are full-grown within about six weeks, but in case they hatch before the leaf buds of their food plants have burst, their development is retarded by lack of food. Cold or inclement weather soon after the

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14 Amer. Ent. and Bot., 2: 261.

young caterpillars have hatched also delays their growth. Dr. Riley[15] states that the newly hatched caterpillars are able to fast fully three weeks and "to withstand any amount of inclement weather."

Feeding habits.—During the first three or four weeks the caterpillars are gregarious, but as they approach full size, and especially after the last molt they scatter about the tree. During the earlier stages only a portion of the leaf is consumed, but later nearly the entire leaf may be devoured. Weed states[16] that "the caterpillars commonly eat through the leaf in such a way that the outer end drops to the ground," thus causing the insect to be relatively more destructive than if devouring the entire leaf. They feed chiefly during the night, and to a limited extent during the cool of the day. While not feeding they were often seen last season resting in small groups upon the leaves, as shown in Plate XXI, fig. 2, which is from a snap-shot taken on a very warm day at 11:15 A. M. The nature of the injury to the leaves is also shown in this picture.

Silk spinning habit.— From the first the young caterpillars spin a thread of silk wherever they go, but seldom if ever make a true nest. Sometimes a few leaves that the caterpillars have passed over will become covered with silk and attached to adjoining leaves, thus giving the whole the appearance of a rude nest or tent. If disturbed the young caterpillars will drop quickly to the ground. In the bulletin just referred to Dr. Weed reports an observation by Mr. W. F. Fiske to the effect that the young caterpillars when suddenly disturbed while feeding will drop to the ground without attaching a thread. This is also true of the older caterpillars. When congregated upon a twig the young caterpillars are more apt to attach a thread which, however, is quite likely to be broken before the ground is reached. This habit of dropping to the ground when disturbed, as they undoubtedly often are by birds or by the branches swaying in the wind, probably, as

15 Amer. Ent. and Bot., 2: 262.

16 N. H. Agr. Exp. Sta. Bul. 64, pp. 83–84.

Weed has stated,* accounts in part, at least, for the large numbers of caterpillars that are seen crawling up the trunks of infested trees. Observations upon caterpillars in confinement showed that much less silk is spun after the last molt while crawling about than during the earlier stages.

Sharing a nest with the apple-tree tent-caterpillar.—What is probably a very unusual occurrence is shown at Plate XXII, fig. 1. This nest was made by a colony of apple-tree tent-caterpillars. It will be observed that most of the caterpillars in sight are not the rightful owners of the nest, but are forest tent-caterpillars. The two species can be easily distinguished as the apple-tree tent-caterpillars have a conspicuous white line extending the whole length of the back, while the forest tent-caterpillars have the line replaced by a row of white spots. This nest was on an apple tree near the Station grounds. At the time this picture was taken, about 10:30 A. M., the caterpillars had collected on the sunny side of the nest. There were none on the opposite side. The writer watched this nest for several days and it was observed that the "guests" went out regularly with the other species to feed and returned with them. Upon no occasion, however, were the forest tent-caterpillars seen to enter the nest. Upon the fourth day the nest was cut open and although it was well filled with apple-tree tent-caterpillars none of the forest tent-caterpillars could be found. A few days after these observations were made Mr. G. G. Atwood reported finding a similar case in an apple orchard a few miles distant. Although it is not uncommon to find two or three stray forest tent-caterpillars upon one of the nests of their near relatives, such cases as the above appear to be quite unusual.

Congregating habit.—A very noticeable habit is that of congregating in large numbers on the trunks and branches of the infested trees. There appear to be two principal occasions for this, first, when resting during the heat of the day and, second, when about to molt. As an indication of the former, the writer

has observed the caterpillars disperse toward evening after having remained together during the greater part of the day. When about to molt their usual places for congregating are upon the branches and trunks of the infested trees. The young caterpillars are more often found upon the former and those that are nearing fully growth upon the latter or on the large limbs of the larger trees. Plates XXIII is from a photograph of a group of caterpillars, most of which were not more than half grown, upon a limb of a young basswood tree. This photograph was taken at 11:30 A. M. In the sections of the State where the caterpillars were very abundant they were frequently found together, when preparing to molt, in such large numbers as to completely cover one side of the trunk of a full-grown sugar maple tree to the distance of three or four feet. Plate XXIV is from a photograph taken at 3:15 P. M., of a comparatively small group of caterpillars about two-thirds grown upon a small plum tree in an orchard near Geneva.

Restlessness of the full-grown caterpillars.—After the last molt the caterpillars become very restless, wandering up and down the trunks, along fences, etc., until finally the cocoons are spun. It has been observed that they feed but little during this period. This was also indicated by the colonies kept in our breeding cages. After the last molt they ate but very little, wandering about for three or four days and finally spinning their cocoons in all parts of the cages.

Number of molts and descriptions.— The number of molts is usually four. A fifth molt occurs soon after the cocoon is spun. The molting periods, with the exception of the first, which was not observed, of a large number of caterpillars confined in breeding cages last spring were as follows: The first molt was about May 8, the second May 16, the third May 31. About ten days later part of them molted a fourth time and within three days spun their cocoons. A small proportion of those that molted but three times spun cocoons. The remainder died. This lack of normal development was probably due to insufficient food as they were accidentally deprived of fresh food for nearly two days be-

tween the third and fourth molts. The periods of molting and the markings were observed and recorded by C. V. Riley[17] in 1870. The following descriptions do not differ essentially from those given by him. The caterpillars just after leaving the eggs measure on the average 2 mm. in length. They are dull black in color with long grayish-white hairs arising from numerous minute tubercles. In a few days there is a slight change in color. The middle of the body becomes lighter, taking on a brownish tinge, while the extremities remain darker. The tubercles also become more distinct and a dark interrupted line conspicuous along each side. These markings become more prominent as the time for the first molt approaches.

The first molt.— The first molt occurs from ten days to three weeks after the caterpillars emerge from the eggs, the variation in time probably depending upon the abundance of the food supply. Immediately after the first molt they measure about one-half inch in length. There are two pale yellowish sub-dorsal lines bordering the dark lines above referred to. These lines become more conspicuous as the time for the second molt approaches; the dorsal spots are also indistinctly seen.

The second molt.— This molt occurs from a week to ten days after the first when the length is about three-fourths of an inch. A row of eleven cream-white somewhat diamond shaped or club-shaped spots extends the full length of the back. Also as Dr. Riley states in the reference above given: "The upper pale line becomes yellow, the lower one white, and the space between them bluish."

The third molt.— The third molt occurs about a week to ten days after the second. The caterpillars measure about one inch in length. There is little change in the markings except that they become more distinct.

The fourth molt.— Between the third and fourth molts is the most rapid-growing period of the larval life. After the fourth

17 Amer. Ent. and Bot., 2: 262.

molt they measure from one and one-half to two inches in length. Last spring caterpillars that measured two inches were quite common and a few were found that measured two inches and a quarter.

The following technical description is by Dr. Asa Fitch.[18]

"The caterpillar, after it has forsaken its nest and is wandering about, is an inch and a half long and 0.20 thick. It is cylindrical and of a pale blue color, tinged low down on each side with greenish-gray, and is everywhere sprinkled over with black points and dots. Along its back is a row of ten or eleven oval or diamond-shaped white spots, which are similarly sprinkled with black points and dots, and are placed one on the fore part of each segment. Behind each of these spots is a much smaller white spot occupying the middle of each segment. The intervening space is black, which color also forms a border surrounding each of these spots, and on each side is an elevated black dot, from which arise usually four long, black hairs. The hind part of each segment is occupied by three crinkled and more or less interrupted pale orange-yellow lines, which are edged with black. And on each side is a continuous and somewhat broader stripe of the same yellow color, similarly edged on each of its sides with black. Lower down on each side is a paler yellow, or cream-colored stripe, the edges of which are more jagged and irregular than those of the one above it, and this stripe also is bordered with black, broadly and unevenly on its upper side and very narrowly on its lower side. The back is clothed with numerous fine fox-colored hairs, and low down on each side are numerous coarser whitish ones. On the under side is a large, oval, black spot on each segment, except the anterior ones. The legs and pro-legs are black and clothed with short whitish hairs. The head is of a dark bluish color, flecked with numerous black dots and clothed with short blackish and fox-colored hairs. The second segment, or neck, is edged anteriorly with cream white, which color is more broad upon the sides. The third and fourth segments have each a large black spot on each side. The instant it is immersed in spirits, the blue color of caterpillar vanishes and becomes black."

By referring to Plate XXII, fig. 2, the difference in the dorsal markings of the two common species of tent-caterpillars will be plainly seen. The caterpillar on the left is an apple tree tent-caterpillar, the other two are forest tent-caterpillars, the one on the right being a lateral view. All are nearly full-grown and are natural size.

The cocoon.— The cocoons are made of coarse white silk which soon becomes discolored by the weather. In size and shape they

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18 **Fitch. Fifth Report on the Insects of New York, p. 821.**

closely resemble those of the apple tree tent-caterpillar described on pages 286–287 of Bulletin 152 of this Station, but are somewhat more loosely woven and have less of the yellowish powder. In the vicinity of Geneva the spinning of the cocoons began last season about the last week in May and continued until the middle of July.

Although it has been considered one of the characteristics of this species to utilize a leaf in making the cocoon there were many exceptions last season, for they were found in great numbers upon the fences and out-buildings and even upon the ground, where no leaves were to be had to aid in their construction. This may have been in part due to a scarcity of foliage in the woodlands where the trees had been entirely stripped. In sections where the caterpillars were less common, most of the cocoons were formed in the leaves, the leaf or leaves being brought around the cocoon as shown at Plate XXI, fig. 3. This picture shows a cocoon partly enclosed by two elm leaves held in place by the numerous threads of silk attached to them. Some of the forest tent-caterpillars kept in the breeding cages showed a tendency to forsake this habit; for out of about 150 over half spun their cocoons upon the sides of the cages, the remainder utilizing the leaves that were there in abundance. Most of these caterpillars spun their cocoons during the night, but a few kept in a darkened room began during the latter part of the afternoon. These were observed to require between five and six hours to complete the work. After completing the cocoon the imprisoned caterpillar molts once and then passes to the pupa stage.

The pupa.— Both male and female pupæ are reddish-brown in color. The former measures about five-eighths of an inch in length and the latter three-fourths.

Moths: time of appearance; habits.—Last spring in the vicinity of Geneva the moths were occasionally seen by June 20. A large number of the cocoons gathered from various parts of the State where the caterpillars were very abundant furnish interest-

ing data as to the length of time during which the moths are issuing, the percentage of males and females and the percentage parasitized. As will be observed the moths issued from these cocoons from June 26 to July 8. The data in the following table was obtained from 2,500 of the cocoons.[19]

EMERGENCE OF MOTHS FROM COCOONS OF FOREST TENT-CATERPILLAR.

Dates.	Males	Females
June 26	3	14
June 27	10	10
June 28	10	2
June 29	42	11
June 30	31	5
July 1	73	67
July 3	342	284
July 4	75	84
July 5	132	132
July 6	64	98
July 8	12	25
	794	672

Total males and females	1,466
Number of cocoons parasitized	312
Number cocoons unhatched.	722

These figures show that a little over 40 per ct. of the 2,500 cocoons failed to produce moths. Also that less than 47 per ct. of those that hatched were females and that the greatest number of moths escaped during the first five days of July. A little over $12\frac{1}{2}$ per ct. were parasitized and more than 28 per ct. produced neither moths nor parasites.

The moths are active, restless insects. They fly only at dusk and during the night. The females are ready to lay eggs soon

[19] Cocoons to the number of 3,757 were sent in from various sections of the State. Nearly 1,000 of them had hatched before being gathered, leaving about 2,700 unhatched. For most of these cocoons the writer is indebted to Mr. A. R. Eastman, Waterville N. Y., Mr. D. H. Burrell, Jr., Little Falls, N. Y., Mr. J. B. Tuckerman, Cassville, N. Y., and Mr. J. M. Budlong, West Schuyler, N. Y.

after leaving the cocoons, but probably live but a short time after the eggs have been deposited. Some female moths kept in the breeding cages laid their eggs within two days after escaping from the cocoon and died before the end of the third day.

Descriptions.— In general the moths resemble those of the apple-tree tent-caterpillar except that the oblique lines across the fore-wings are dark instead of light in color. The general color of typical specimens is buff with a brownish tinge. An examination of a large number of moths showed a wide variation from this even in the individuals that do not approach the varieties, referred to on a subsequent page. Both wings and body are subject to decided shadings of either a yellow or brownish cast. A male moth of average size spreads about one inch, but in the moths reared last spring a few were found that spread but $\frac{7}{8}$ inch and a few that spread $1\frac{1}{8}$ inches. There is less variation in the markings of the females but an equal or greater variation in size. A female of average size was found to spread $1\frac{3}{8}$ inches, the smallest $1\frac{1}{4}$ inches and the largest $1\frac{3}{4}$ inches. The two upper rows of moths on Plate XXV show the variation in size. The upper row are males and the second row females.

The following detailed descriptions of the male and female moths are by Dr. Asa Fitch.[20]

"The male moth usually measures 1.20 inches across its spread wings. Its thorax is densely coated with soft hairs of a nankin-yellow color. Its abdomen is covered with shorter hairs, which are light umber or cinnamon brown on the back and tip and paler or nankin-yellow on the sides. The antennæ are gray, freckled with brown scales and their branches are very dark brown. The face is brown, with tips of the feelers pale gray. The fore-wings are gray, varied more or less with nankin-yellow, and they are divided into three nearly equal portions by two straight dark brown lines, which cross them obliquely, parallel with each other and with the hind margin. * * * The fringe is of the same dark brown color, with the oblique lines, with two whitish alternations towards its outer end. But some times it is of the same color with the wings, and edged along its tip with whitish. The hind wings are of a uniform pale umber or cinnamon brown, sometimes broadly grayish on the outer margin and across their middle a faint darker brown band is usually

20 Fitch, Asa. Fifth Report, p. 822.

perceptible, its edges on each side indefinite. The fringe is of the same color with the wings, or slightly darker, and is tipped with whitish. The under side is paler umber brown, the hind wings often gray, and both pairs are often crossed by a narrow, dark brown band, which, on the hind wings, are curved outside the middle. All back of this band, on both wings, is often paler, and more so near the band."

"The female is 1.75 inches wide, and in addition to the shortness of the branches of her antennæ, differs from the male in her fore-wings, which are proportionally narrower and longer, with their hind margin cut off more obliquely, and slightly wavy along its edge. Hence, also the dark brown lines cross the wings more obliquely, the hind one in particular forming a much more acute angle with the outer margin. And all the wing back of this line is sometimes paler or of a brownish, ashy color. And the fringe of these wings has not the two whitish alternations which are often so conspicuous in the male. The head and fore part of the thorax is cinnamon brown. The abdomen is black, clothed with brown hairs, though very thinly so on the anterior part of each segment, where these lines are intermingled with silvery gray scales."

Varieties.— Two varieties of this species have been described. Numerous specimens of both were reared from the cocoons above referred to. They are as follows:

Variety *sylvatica* Harr. has the space between the lines filled in forming a broad brown band across each anterior wing. Plate XXV, third row; the two on the left are males and the third a female.

Variety *thoracicoides* Neumoegen and Dyar, has the bands wanting or very obscure. Plate XXV, fourth row; all males.

Among the specimens reared in the laboratory there was an interesting series showing a gradual gradation from the light typical form with the two well marked bands, to the variety *sylvatica* having the space between filled in with brown forming the broad bands as above described. Plate XXV, fifth row.

SUMMARY OF LIFE-HISTORY.

In the latitude of New York State the eggs are usually laid during the last week of June and until about the second week of July. They are placed in bands extending around the twig and are covered with a shining frothy glue. The caterpillars are fully formed in the eggs before the summer is over, but do not escape until early the following spring. They feed upon the foliage of a

large variety of trees and shrubs. They spin a thread of silk wherever they go, but do not build nests. When not feeding or when about to molt they gather often in large numbers upon the limbs or trunks of the infested trees. Pupation takes place during the latter part of May or early in June, the cocoons being placed either upon the leaves or in almost any locality near the ground. The moths appear during the latter part of June and early July. The eggs are at once laid. There is but one annual brood.

NATURAL CHECKS.

The same natural agencies mentioned in Bulletin 152, page 289, as operating against the apple-tree tent-caterpillar probably have an equal influence upon this species. In addition to unfavorable climatic conditions, birds, insects and diseases have a marked effect upon this species. According to Kirkland[21] the common garden toad also feeds upon the caterpillars.

Birds.—A careful study of the birds in the sections of the State which were infested with the caterpillars last spring would undoubtedly have revealed many species not recorded here feeding upon this insect in its various stages. Reports from careful observers together with limited observations by the writer indicate that the following birds feed upon this insect in some of its stages: The black-capped chickadee feeds upon the eggs probably chiefly during the winter when other animal food is not abundant. The writer has taken the eggs from the stomachs of chickadees shot during the winter in localities where the caterpillars were not especially abundant. The yellow-billed cuckoo, Baltimore oriole, American red start, cat bird and robin feed upon the caterpillars. In addition Weed[22] reporting the observations of Miss Soule records chipping sparrows, red and white-eyed vireos, cedar bird, and nut-hatches feeding upon the caterpillars; chickadees upon the cocoons; and robins, chipping sparrows, yel-

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21 Mass. (Hatch) Agr. Exp. Sta. Bul. 46, pp. 22 and 25.

22 Bul. 64, N. H. Agr. Exp. Sta., pp. 91–92.

low birds and English sparrows feeding upon the moths. Undoubtedly many more of our smaller birds feed upon the young caterpillars.

Predaceous insects.— The predaceous insect enemies herein recorded may be divided into two groups: The coleopterous (beetles) and the hemipterous (bugs). The caterpillars fall an easy prey to these enemies when crawling about upon or near the ground. The following are included in the first group: *Calosoma scrutator* Fab., and *Calosoma calidum* Fab., two of our largest species of predaceous ground-beetles, which have frequently been observed attacking caterpillars of various species. Dr. C. V. Riley[23] and Mr. Wm. Saunders[24] were probably the first to record them feeding upon the caterpillars of this species.

According to Felt,[25] Burgess states that *Calosoma wilcoxi* LeC. fed readily in confinement upon the caterpillars. Included in the second group are the two predaceous bugs, *Podisus placidus* Uhler and *Podisus seriventris* Uhler, which Kirkland[26] has recorded feeding upon the caterpillars. Saunders records[27] a species of *Trombidium* feeding upon the eggs.

Parasitic insects.— The parasitic insect enemies may also be divided into two groups: The dipterous parasites and the hymenopterous parasites. Of the former group Coquillett[28] records the following as parasites of the caterpillars: *Euphoracera claripennis* Macq., bred by C. H. Fernald, Amherst, Mass., *Frontinia frenchii* Will., previously recorded by Harvey[29] and *Tachina mella* Walk. also previously recorded by Harvey. During the past season the writer has also bred the last named species together with *Calliphora erythrocephala* Meigen, which Coquillett states is

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23 Amer. Ent. and Bot., 2: 265.

24 Insects Injurious to Fruits, p. 57.

25 Bul. N. Y. State Museum, No. 23, p. 196.

26 Mass. (Hatch) Agr. Exp. Sta. Bul. 46, p. 25.

27 Ann. Rept. Ent. Soc. Ont., 1878, p. 28–30.

28 Bul. No. 7, U. S. Dept. Agr., Div. Ent., Tech. Series, pp. 11, 16, 21, 24.

29 Psyche, May, 1891, p. 85.

evidently a scavenger. Both species were kindly identified by Mr. D. W. Coquillett.

The second group, the hymenopterous parasites, are probably more effectual in keeping the forest tent-caterpillar and other insects in check, because they are usually much more abundant. The following species have been recorded as preying upon the caterpillars: *Limneria fugitiva* Say, recorded[30] by Riley, and *Pimpla pedalis* Cres., by Wm. Saunders.[31] From the 2,500 cocoons kept by the writer in the laboratory 287 individuals of the species *Pimpla conquisitor* were reared, of which 218 were females, leaving 69 males; *Pimpla pedalis,* two females and one male; *Theronia fulvescens,* one male. The following species kindly identified by Mr. Wm. H. Ashmead, assistant curator of the U. S. National Museum, were also reared from these cocoons: *Diglochis* (*Phromalus*) *omnivorous* Walk.; *Miotiopis clisicampae* Ashm. As shown on page 304 but 312 or only about 12½ per ct. of the 2,500 cocoons were parasitized.

Disease.—A disease, evidently bacterial, attacked many of the caterpillars last season materially reducing their numbers. This appears to be the same disease that attacks the apple-tree tent-caterpillar mentioned in Bulletin 152, page 291.

COMBATING THE INSECT.

Owing principally to the fact that the caterpillars attack a large variety of trees, this subject is a somewhat complicated one. In badly infested localities, however, it has three distinct phases. First, combating the insect in the forest; second, combating the insect when attacking shade trees; and third, combating the insect in the orchard. We will discuss the subject under each of the three heads, reversing the order given above.

Combating the insect in the orchard; destroying the eggs.—After the leaves have dropped the egg masses are somewhat conspicuous. When pruning the trees they should be carefully

30 Insect Life, 3: 157.

31 Insects Injurious to Fruits, p. 57.

looked for and destroyed. If the orchard has been badly infested it will pay to make a special search for them.

Destroying the caterpillars.— Many methods have been suggested for destroying the caterpillars but there are three especially feasible ones, which, if carefully carried out, will usually prove effectual.

First, spraying with an arsenical compound.—Any good arsenical will answer the purpose if applied before the caterpillars are half-grown. Some of the principal arsenical insecticides are Paris green, green arsenite and arsenite of lime. For a discussion of green arsenite and arsenite of lime see Bulletins 143 and 152 of this Station. A third arsenical, arsenate of lead, has been found by the Gypsy Moth Commission of Massachusetts to be especially effectual against the gypsy moth and to be almost harmless to foliage. The formula is as follows: 11 ounces acetate of lead, 4 ounces arsenate of soda, 150 gallons of water. The directions for making arsenate of lead as given by Professor C. H. Fernald[32] are as follows: "Arsenate of lead is easily prepared by putting 11 ounces acetate of lead in 4 quarts of water, in a wooden (not metal) pail, and 4 ounces of arsenate of soda (50 per ct.) in 2 quarts of water in another wooden pail, and when entirely dissolved mixing them in a hogshead containing 150 gallons of water, when a chemical reaction will take place forming arsenate of lead in a fine white powder in suspension of water. If cold water be used in the wooden pails, the solution of the acetate of lead will require a little time, but, however, if the water be hot, it will dissolve very quickly. It is customary to add from 2 to 4 quarts of glucose to the above amount of water. If it is desired to use larger proportions of the arsenate of lead, it is only necessary to use more acetate of lead and arsenate of soda, but *always* in the proportions given above." To ensure success in spraying two points should be kept in mind, namely, promptness and thoroughness. The poison will be much more effective if applied before the caterpillars are

[32] Ann. Rept. Mass. Bd. Agr. 1897.

one-fourth grown and of but little avail if the application is delayed until after they are half grown.

Second, destroying the caterpillars when they have assembled upon the trunks or large branches.— This may be done in any convenient way. A very easy way is to crush them with an old broom which, to insure the death of all the caterpillars it touches, has been dipped in kerosene oil. The kerosene oil is fatal to them, and if preferred may be sprayed directly upon them.

Third, jarring and banding.— Jarring is seldom practical except with small trees. The tree should be given a few quick, sharp raps with a padded mallet. The caterpillars will drop at once and may be collected and destroyed in curculio carts or upon sheets spread upon the ground.

Banding is for the purpose of preventing those caterpillars that have been jarred off by the wind, or by birds, or have left the tree during the restless period just previous to pupating, from again ascending the trunk; also to protect the trees from invading caterpillars, especially when the orchard is situated near infested shade or forest trees. The bands may be made of cotton wool in which the caterpillars will become entangled, or better by some sticky substance such as tar mixed with two parts of raw oil, or with raupenleim. Either of these substances should be smeared upon bands of paper at least a foot wide which can be tied around the trunks of the trees. By using the paper there is no danger of injury to the bark. Sticky fly paper is sometimes successfully used in the same way. The caterpillars will be caught upon these bands and soon die. Where the caterpillars are very abundant so many will be caught upon the bands that other caterpillars can crawl safely over them. In such an event new bands will have to be applied or the originals made wider. Of these sticky substances raupenleim is one of the best. It can be obtained of William Meuzel & Co., 64 Broad St., New York, and the Bowker Fertilizer Co., Boston. It should never be applied directly to the bark.

Collecting the cocoons.—Many of the cocoons are spun in places where they can be easily reached. In collecting and destroying them many useful parasites would be destroyed but in case of a serious outbreak the thorough collecting of the cocoons would accomplish more immediate good than the parasites. It would, however, be but little trouble to place the cocoons under a coarse netting and leave them until the parasites had escaped. The netting should be too fine to allow the moths to pass but coarse enough to allow the parasites to escape.

Capturing the moths.—As previously stated the moths fly at dusk or later. They are attracted by a bright light, and may be captured by placing a lighted lantern over a tub of water, over which enough kerosene oil has been poured to make a thin film. The moths flying about the light will fall into the water. While this method may be of some value it is doubtful if many female moths will fly to the light before having deposited their eggs, after which of course, it makes no difference whether they are attracted to the light or not.

Combating the insect when attacking shade trees.—All of the methods just described can be used to check the insect when attacking small shade trees. For large trees banding is of much value. In some of the villages in which the caterpillars were abundant last spring, they were dislodged from the large trees by streams of hydrant water and prevented from going back up the trunks by the sticky bands. For spraying the large trees special apparatus is required. Steam power is usually used. A suitable outfit can be purchased for from about $200 up. The increase of shade tree insect pests and diseases make it almost necessary for a village to own a spraying apparatus to ensure the preservation of its shade trees.

A method of combating the insects which has been tried with success is to encourage the school children to collect the egg masses by paying them a reasonable price per hundred. This may be done by the private individual or by the village or city authori-

ties. In either case the expense would be trifling in comparison with the good accomplished.

Combating the insect when attacking forest trees.—When the caterpillars occur in such great numbers over such wide areas of woodland as they did last spring it is difficult to devise a method of destroying the caterpillars that would be practical for individual farmers to undertake. Banding the trees will be of much value. Also with comparatively little work many of the caterpillars which have assembled on the trunks can be destroyed. Whatever is done a united effort will be necessary to give the best results.

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Munson, W. M. Rural New Yorker, 58: 421. Recommends lead and sulphur, equal parts, put on paper and tied around trunks to prevent caterpillars ascending.

DESCRIPTION OF PLATES.

Plate XX.— Area over which the caterpillars were most destructive in New York State during 1899.

Plate XXI.— 1. *Egg mases, natural size.* 2. *Caterpillars at rest during the heat of the day.* 3. *Cocoon between two elm leaves, natural size. (Original.)*

Plate XXII.— 1. *Nest of apple-tree tent-caterpillars containing both species.* 2. *Showing principal difference in markings between the two species. The one on the left is the apple-tree tent-caterpillar, all about two-thirds grown. Natural size. (Original.)*

Plate XXIII.— Young caterpillars congregated upon a small basswood branch. (Original.)

Plate XXIV.— Caterpillars congregated upon trunk of plum tree preparing for last molt. (Original.)

Plate XXV.— First two rows male and female moths of Clisiocampa, disstria *Hubn, showing markings and variation in size. Third row,* C. disstria *var.* sylvatica *Harr; the two on the left are males and the third a female. Fourth row,* C. disstria *var.* thoracicoides, *Neumoegen and Dyar; all males. Fifth row shows gradation from light form with two narrow dark lines across each fore wing to dark form with dark band across the wings; all males. All natural size. (Original.)*

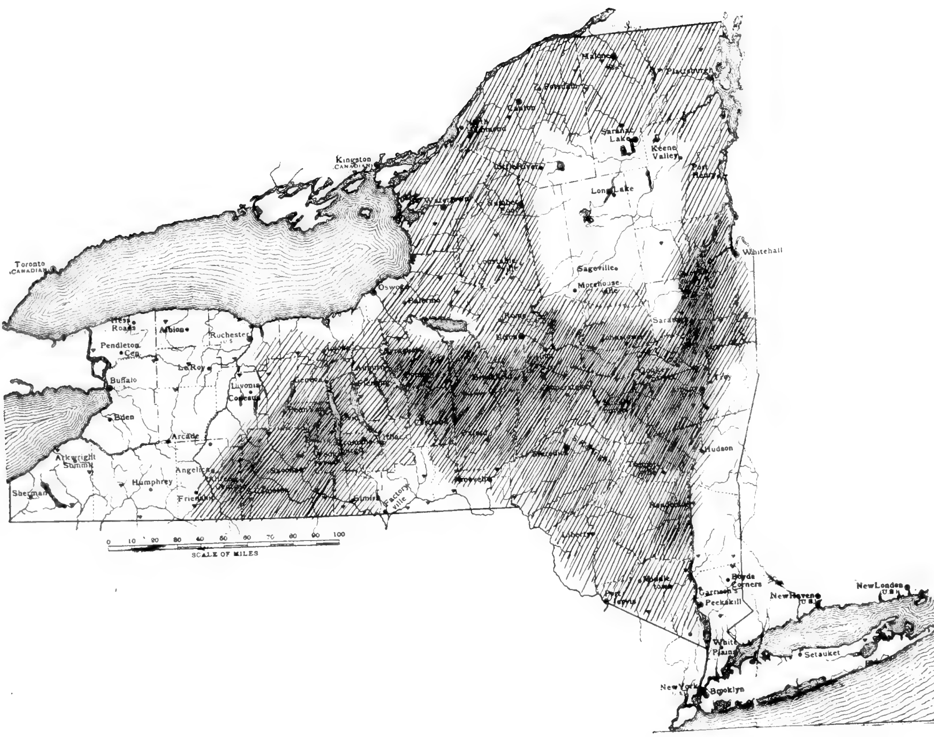

Toronto
Kingston
Whitehall
Oswego
Rochester
Buffalo
Pendleton Cen.
Albion
Le Roy
Livonia
Conesus
Eden
Arcade
Arkwright Summit
Sherman
Humphrey
Angelica
Friendship
Sageville
Morehouse-ville
Long Lake
Saranac Lake
Keene Valley
Port Henry
Hudson
Liberty
Port Jervis
Peekskill
Boyds Corners
New Haven
New London
Setauket
White Plains
New York
Brooklyn
Factoryville
SCALE OF MILES
0
10
20
30
40
50
60
70
80
90
100

PLATE XX.

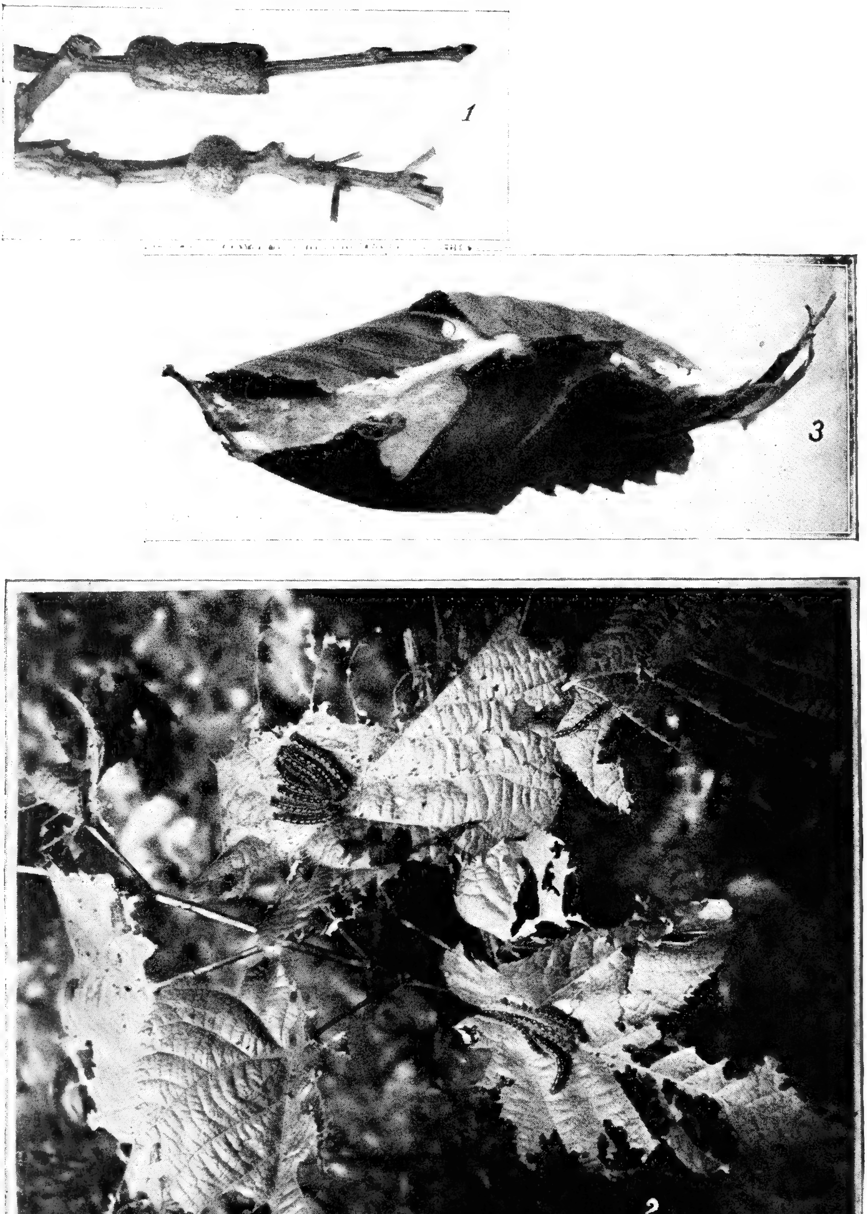


Plate XXI.

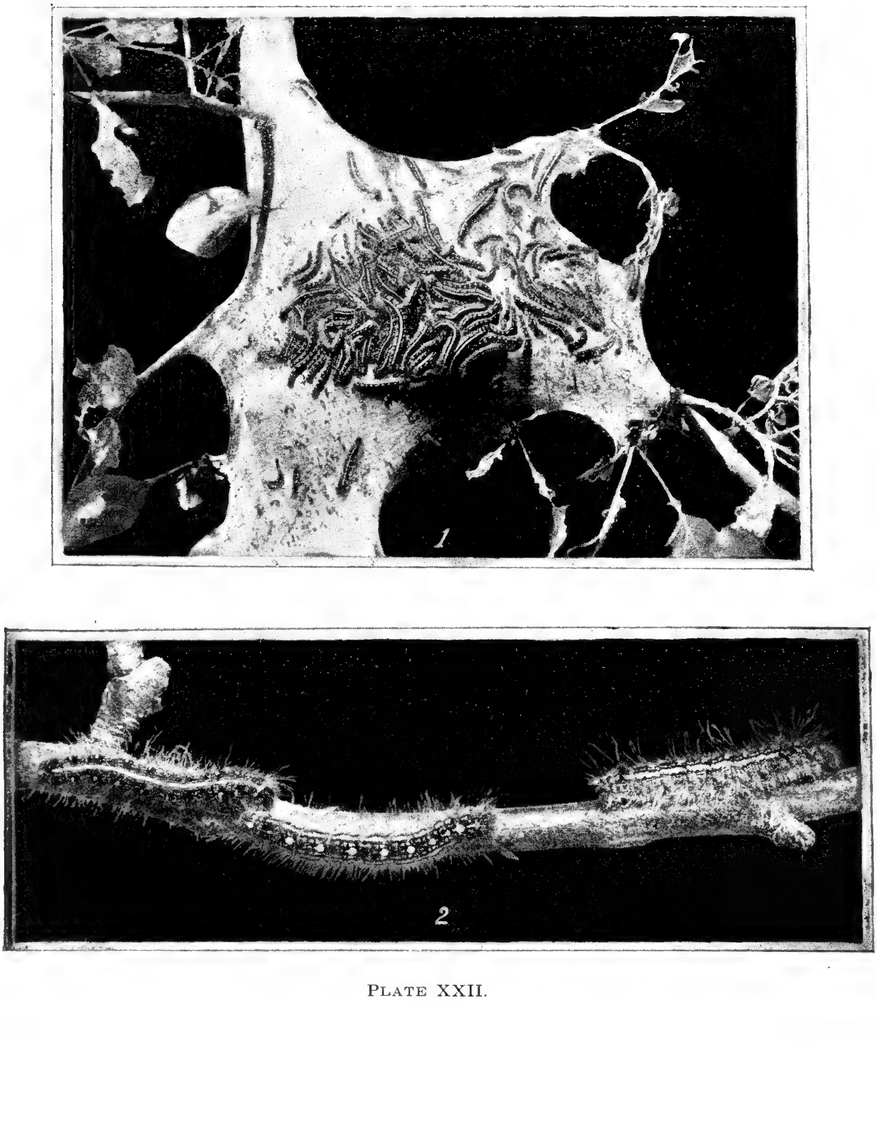


PLATE XXII.

PLATE XXIII.

Plate XXIV.

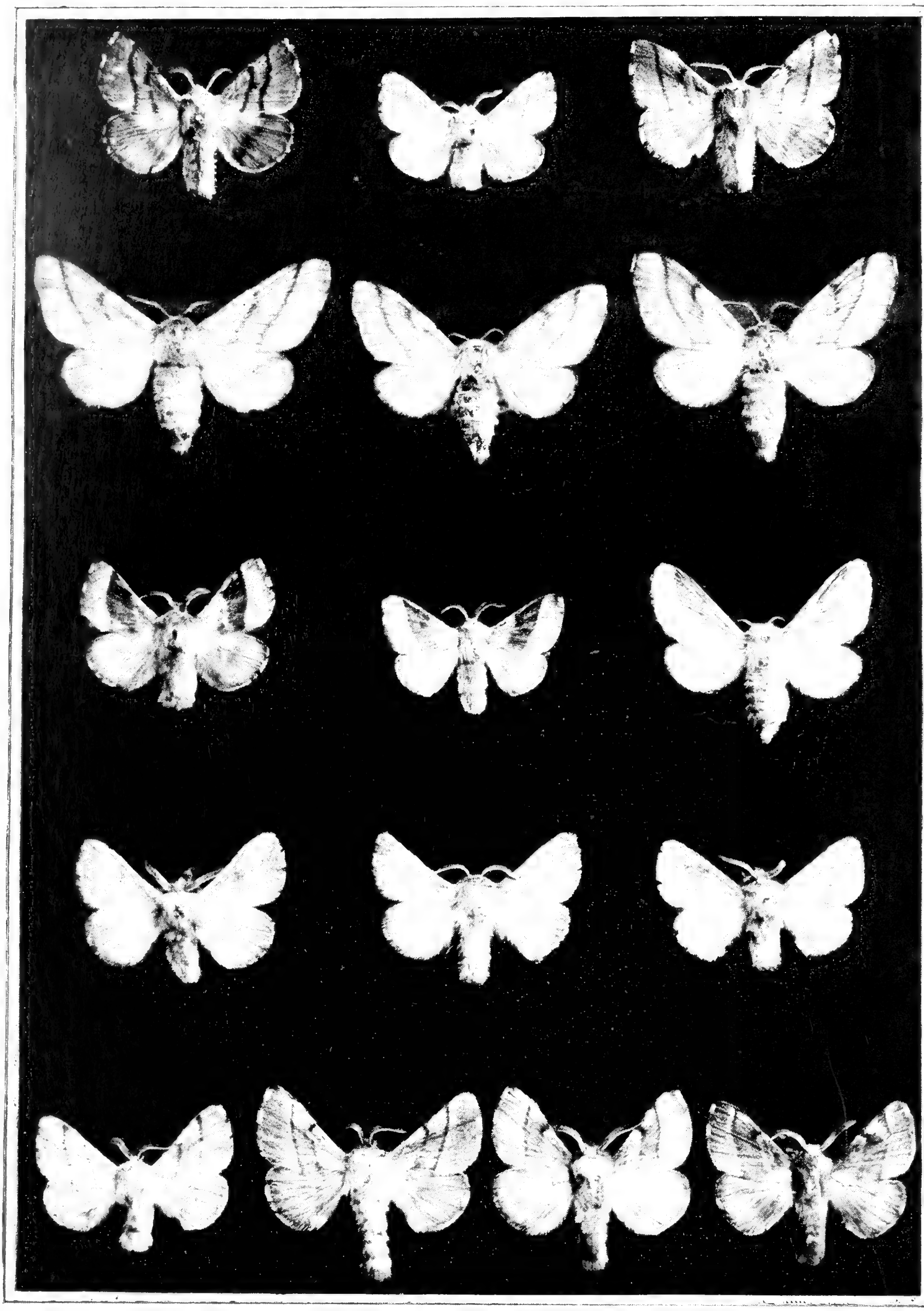


Plate XXV.

REPORT

OF THE

Horticultural Department.

S. A. BEACH, *Horticulturist.*
WENDELL PADDOCK, *Assistant.*
C. P. CLOSE, *Assistant.*

TABLE OF CONTENTS.

I. Treatment for gooseberry mildew.
II. The New York apple-tree canker.
III. Fertilizing self-sterile grapes.
IV. Common diseases and insects injurious to fruits.

REPORT OF THE HORTICULTURIST.

TREATMENT FOR GOOSEBERRY MILDEW.*

C. P. Close.

SUMMARY.

For three seasons, Bordeaux mixture, lysol and formalin have been compared with potassium sulphide, the latter giving the best results in all three series.

The Bordeaux mixture proved comparatively valueless, as in but one series of tests did treated bushes show less mildew than check bushes; formalin in the strongest solution, 1 oz. to 1 gal. water, gave fair results, but weaker solutions ranked with the Bordeaux mixture; lysol gave promising results, coming next to the potassium sulphide in reduction of mildew injury.

With one exception, Bordeaux mixture, very early spraying gave better results than medium early or late treatments.

Winter treatment was tested during one season, but did not give sufficiently favorable results to justify recommendation.

INTRODUCTION.

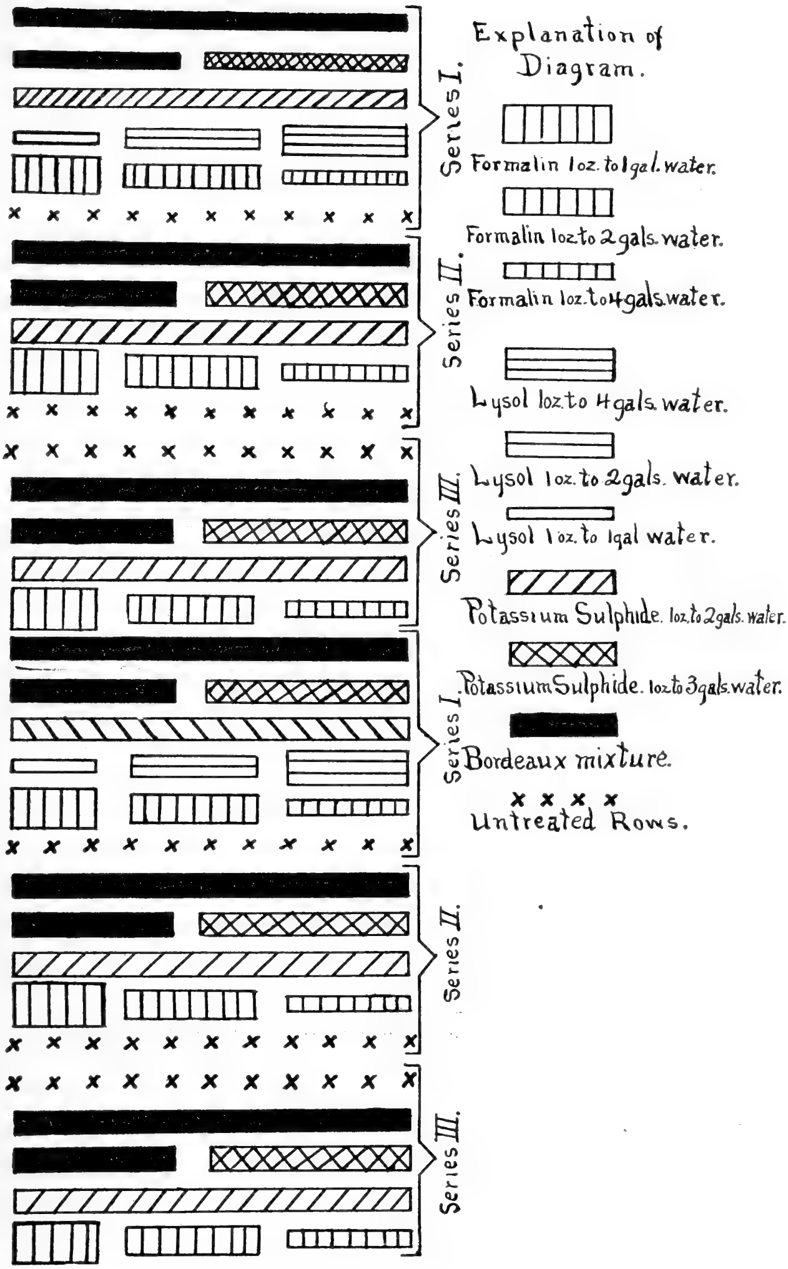
The gooseberry mildew generally makes its appearance during the last half of May or first half of June. It is first noticed as glistening, frost-like spots on the fruit on the lower part of the bush where there is usually dense shade. As the disease progresses the spots enlarge, turn dark brown and form a felt like covering over a part, or all, of the berry. In a slight attack the disease

* **Reprint of Bulletin No. 161.**

may not injure the fruit at all, or only slightly deform it. In a bad attack the fruit has a repulsive appearance, is stunted in development, and may be more or less decayed.

Two or three weeks after the mildew attacks the fruit it appears on the young, tender twigs, especially on their tips. If the attack is severe the new growth will be destroyed and the older growth will be considerably injured. In case of a very severe attack the fruit will be rendered worthless, and the foliage will be nearly, or entirely, killed during July. As a result no fruit buds are set for the next year's crop, and the bushes are so badly weakened that they may suffer from winter injury. In a few commercial plantations where little or no spraying has been done the writer has seen the crop of fruit destroyed and the bushes practically ruined by this disease. In other plantations where spraying was carefully done the greater part of the crop was saved, the foliage remained in good condition and fruit buds were set for a succeeding crop. The extent to which mildew can be prevented by spraying depends upon weather conditions and location. In a wet season like that of 1898 it flourishes abundantly and is difficult to control. The disease, as already stated, usually obtains a foothold on the lower parts of the bushes where the shade is dense. These parts are very difficult to reach thoroughly with spray solutions, and in a year when the other conditions favor the spread of the fungus, are liable to harbor more or less of the disease unless the greatest care and thoroughness are used in spraying. In a dry season like the present one mildew can be almost entirely prevented by thorough use of fungicides. On uneven ground the higher parts of a plantation seem to be less subject to the disease than the lower parts. The best location seems to be one well elevated, with a gradual slope affording good air drainage.

In view of the destructive character of gooseberry mildew and its economic importance in all parts of America where gooseberries are grown, either for home use or for market, it was decided to undertake experiments in treating the disease on a commercial scale. The object of the experiments was to compare the potassium sulphide treatment with treatments with other fungicides


Series I.
Series II.
Series III.
Series I.
Series II.
Series III.
Explanation of Diagram.
Formalin 1oz. to 1gal. water.
Formalin 1oz. to 2gals. water.
Formalin 1oz. to 4gals. water.
Lysol 1oz. to 4gals. water.
Lysol 1oz. to 2gals. water.
Lysol 1oz. to 1gal water.
Potassium Sulphide. 1oz. to 2gals. water.
Potassium Sulphide. 1oz. to 3gals. water.
Bordeaux mixture.
x x x x
Untreated Rows.

and at the same time to compare very early treatments with later treatments and thus learn at what periods spraying should be done to accomplish the best results.

These investigations were begun in 1897 and have been continued for three seasons. Two commercial plantations have been under experiment. One belonging to King & Robinson is located at Trumansburg on the slopes just west of Cayuga Lake. This was treated three seasons. The other belonging to the Van Dusen Nursery Co., Geneva, and located on the upland about two miles west of Seneca Lake, was treated in 1899 only. A preliminary report giving the results of the work in 1897 may be found in Bulletin 133. A complete report of the investigations for the entire period from 1897 to 1899 is now presented for the first time.

TRUMANSBURG EXPERIMENTS.

PLAN.

The plantation at Trumansburg consists of 32 rows with 11 plants to the row. As shown in the diagram opposite it was divided into six plats. Each treatment was given to two plats located in different parts of the plantation. This arrangement was for the purpose of equalizing for each remedy the differences in soil and location which might exist in different parts of the plantation.

For convenience in comparing the effects of very early with medium and late spraying, three series of treatments were made. Series I was begun very early just as the buds were breaking and successive applications were made at intervals of about ten days until seven had been given. Series II was begun when the second spraying of Series I was made. Series III was begun when Series I received its third spraying and Series II its second spraying. During the remainder of the season the dates of treatment were the same for all three series. An untreated row was left as a check for each series.

FUNGICIDES USED.

Bordeaux mixture (ordinary), 1 to 11 formula, was used until the last two or three sprayings when potassium sulphide, 1 oz. to 2 gallons water, was substituted for it. This substitution was made so that the fruit would not be spotted with Bordeaux mixture at the time it was picked for market.

Lysol and formalin were each used in three strengths, 1 oz. to 1 gal. water, 1 oz. to 2 gals. and 1 oz to 4 gals.; and potassium sulphide in two strengths, 1 oz. to 2 gals. and 1 oz. to 3 gals. water. Applications of these materials were made with a bucket force pump fitted with a Bordeaux nozzle. No injury was done to the foliage by any of the solutions.

OBSERVATIONS AND DATES OF TREATMENTS.

Tests in 1897.— The first spraying was made April 12 just as the buds were bursting. This was followed by applications April 23, May 5, 17, 26, June 7 and 21. The bushes made a good growth and had a good setting of fruit. Mildew was found in small amounts on the fruit May 26. This developed rapidly on the fruit and by June 7 had spread to the new growth. A careful examination revealed less mildew on the bushes treated with potassium sulphide than on the other treated or untreated bushes.

As it was desired to market the fruit green, the last spraying was made June 21 and the fruit was picked early in July.

Tests in 1898.— Owing to the very mild weather early in March the buds began to open and by the middle of the month were in condition for the first spraying. They were not sprayed, however, because it seemed that cold weather must come and check the premature growth, hence it would be useless to spray until continuous growth might be expected. Contrary to expectation the latter part of March was not unfavorable to a slow growth and by April 1 when the first spraying was made the growth was about ten days in advance of what is desirable at the time of first application. Later applications were made April 14, 26, May 9, 21, June 1 and June 13. There was an abundance of moisture

Plate XXVI.—Crown Bob Gooseberry Affected by Mildew. A Perfect Berry in Lower Right Hand Corner.

PLATE XXVII.—STAGES AT WHICH SPRAYING SHOULD BE GIVEN FOR MILDEW.

during the season which seemed to favor a rapid growth of mildew. The disease was first noticed May 25. It was quite generally distributed throughout the plantation but was most abundant on the untreated rows. The fruit was marketed green the latter part of June.

Tests in 1899.— The weather was unfavorable to early growth so the first spraying was not made until April 15. Later sprayings were made April 25, May 5, 15, 25, June 6 and 12.

The season was dry and the attack of mildew was comparatively light, although the bushes made an excellent growth and set a fair crop of fruit. Mildew appeared early in June and was especially noticeable on the check rows and on the under side of bushes sprayed with Bordeaux mixture. The young growth was exempt from the disease. The fruit was picked the last of June.

RESULTS.

Table I shows the different strengths of the various fungicides used and the percentage of mildew for the three years in each series and each treatment in the series.

TABLE I.— PERCENTAGE OF MILDEWED FRUIT FOR THREE SEASONS.

Fungicide.	Series I. Spraying begun very early. Seven applications.			Series II. Spraying begun medium early. Six applications.			Series III. Spraying begun late. Five applications.		
	1897.	1898.	1898.	1897.	1898.	1899.	1897.	1898.	1899.
*Bordeaux mixture:									
1 to 11 formula	37.4	66.7	60.6	29.1	80.9	53.2	58.	90.5	63.
Potassium sulphide:									
1 oz. to 2 gals water..	6.6	29.3	5.5	12.3	42.7	3.5	11.5	37.9	15.1
1 oz. to 3 gals. water..	5.	50.9	6.6	15.1	69.5	7.5	13.	66.3	6.6
Formalin:									
1 oz. to 1 gal. water...	48.8	59.9	8.9	78.3	80.9	11.2	56.	63.4	8.8
1 oz. to 2 gals. water..	59.1	84.	15.	84.7	91.9	14.9	71.4	96.8	37.5
1 oz. to 4 gals. water..	52.6	95.1	16.1	65.	86.7	16.2	70.4	89.1	41.9
Checks	57.7	80.8	22.6	78.7	98.	28.5	78.7	95.7	30.6
Lysol:									
1 oz. to 1 gal. water...	24.5	74.2	6.6	....	....	....	....	....	....
1 oz. to 2 gals. water..	56.8	81.6	8.2	....	....	....	....	....	....
1 oz. to 4 gals. water..	37.1	65.1	10.9	....	....	....	....	....	....

* Last three treatments in each series in 1897, and last two treatments in each series in 1898 and 1899, potassium sulphide, 1 ounce to 2 gallons water.

Table II shows the average percentage of mildew for each series and treatment for three seasons.

TABLE II.— AVERAGE PERCENTAGES OF MILDEWED FRUIT FOR THREE SEASONS.

Fungicide.	Series I.	Series II.	Series III.
Bordeaux	54.9	54.4	70.5
Potassium sulphide:			
1–2	13.8	19.5	21.5
1–3	20.8	30.7	28.6
Formalin:			
1–1	39.2	56.8	42.7
1–2	52.7	63.8	68.6
1–4	54.6	55.9	67.1
Checks	53.7	68.4	68.3
Lysol:			
1–1	35.1	....	....
1–2	48.9	....	....
1–4	37.7	....	....

A comparison of the averages in Table II shows that potassium sulphide treatment, 1 oz. to 2 gals. water, gave the best results in all three series, the best result being in Series I where spraying was begun very early. This shows 40 per ct. less mildew than the check rows do. A weaker solution of the same material gave the next best results and here again the very early treatment of Series I is most favorable, being 23 per ct. better than untreated.

The results with lysol are promising, the strongest solution, 1 oz. to 1 gal. water, reducing the amount of mildew 18 per ct. With formalin, the treatment in Series I, using 1 oz. to 1 gal. water, was much the best, reducing the amount of mildew 14 per ct. In most other cases the tests with formalin rank with the results obtained from the use of Bordeaux mixture, which in Series II only is better than the untreated rows. In Series I and Series III the tests with Bordeaux mixture actually show a larger percentage of mildew than do the check rows. With the exception of Bordeaux mixture in Series II the very early treatments of Series I gave the best results with all tests.

The cost of the material for the remedy giving the best results, potassium sulphide, 1 oz. to 2 gals. water, is about three tenths of 1 cent per bush for seven applications per season.

GENEVA EXPERIMENTS.

PLAN.

The tests were carried on in the Industry plantation of the Van Dusen Nursery Co., near Geneva. During the past few seasons the attacks of mildew here were so severe that the crops were destroyed and many bushes had been either killed outright or so badly weakened that they were winter killed. The part of the plantation used for this work contained 28 rows, 20 bushes to the row.

The general plan of the work in this plantation was much like that for the work done at Trumansburg. The principal new feature was "winter spraying" with several fungicides. This was for the purpose of determining whether or not it would prove practical to spray with strong solutions while the bushes are dormant. The object was to compare the results obtained from bushes given the winter treatment and sprayed throughout the season, with results from bushes where spraying was begun early, medium early and late; also to compare soda-Bordeaux and copper carbonate solutions with potassium sulphide as a preventive of the disease.

WINTER TREATMENT.

The severe weather of winter and early spring prevented the application of this treatment until April 5, but as the buds remained perfectly dormant all that time this date was satisfactory for the test. Each one of the following solutions was applied to a separate row of bushes:

Copper sulphate, 1 oz. to 1 gal. water.

Potassium sulphide, 1 oz. to 1 gal. water.

Iron sulphate, saturated solution, 5 pounds to 1 gal. water, plus 1 per cent of sulphuric acid.

[1]Soda-Bordeaux mixture.— 1pound copper sulphate, 1-3 pound lye, to 5 gals. water.

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[1] A modification of Dr. Halsted's formula, as given in Nineteenth Report New Jersey Exp't Station, p. 336.

Copper carbonate 1 oz., ammonia to dissolve it, 5 gals. water.

Copper carbonate 3.2 oz., sodium carbonate 1.6 oz., ammonia to dissolve them, 5 gals. water.

For the remainder of the season these rows were all sprayed with potassium sulphide 1 oz. to 2 gals. water, six applications being given.

SUMMER TREATMENT.

This part of the work was divided into three series as was the work at Trumansburg. In Series I the work was begun very early, April 18; in Series II medium early, April 28; and in Series III late, May 9. Later applications were made May 23, June 5 and 15.

The various solutions used were:

Pottassium sulphide, 1 oz. to 2 gals. water.

[2]Soda-Bordeaux,—[3]soda (lye) 1 pound.
Copper sulphate 3 pounds.
Lime 5 oz.
Water 30 gals.

[4]Copper carbonate 1 pound, sodium carbonate (sal soda) ½ pound, enough strong ammonia to dissolve the copper carbonate, 50 gals. water.

Ammoniacal solution of copper carbonate,—copper carbonate 5 oz., ammonia 3 pints, water 50 gals.

Each of these solutions was applied to a separate row in Series I, II, and III.

The season was not favorable for the growth of mildew, a small amount appearing on the fruit, but none on the new growth. A very little of the disease was noticed June 15. The bushes made

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2 Halsted, B. D. Nineteenth Report New Jersey Experiment Station, p. 336.

3 "Babbitt's Potash or Lye" was used.

4 This remedy was recommended by Mr. David Allerton and Mr. J. A. Hepworth, of Marlboro, N. Y., who have used it successfully against mildew on American varieties, principally Houghton. There seems to be no reason from a chemical standpoint why sodium carbonate should be used.

a good growth considering the weakened condition they were in in the spring owing to previous serious attacks of the disease.

In all tests a check row was left for comparison. In Series I there was one row of each treatment and one check row set aside for the purpose of clipping off the mildewed tips as they appeared. The object was to determine whether or not it would pay to do this extra labor in a commercial plantation. It was necessary to drop this part of the experiment because no mildew appeared on the tips. A fair crop of fruit was marketed green the latter part of June.

RESULTS.

Table III shows the percentages of mildew from the various tests. Series IV is the part which received winter treatment.

Table III.— Percentage of Mildewed Fruit in Geneva Experiment.

Fungicides.	Series I. Spraying begun very early. Six applications.	Series II. Spraying begun medium early. Five applications.	Series III. Spraying begun late. Four applications.	Series IV. Winter spraying and six applications of potassium sulphide. 1 oz. to 2 gals. water.
Soda Bordeaux — 1 to 10 formula....	1.3	.9	2.2	....
Ammoniacal solution of copper carbonate	2.3	1.2	3.2	....
Strong ammoniacal solution of copper carbonate plus sodium-carbonate.	1.3	1.5	1.8	....
Potassium sulphide, 1 oz. to 2 gals. water	3.5	1.8	3.	....
Checks	7.8	3.4	5.9	....
Copper sulphate, 1 oz. to 1 gal.......	...	...	...	3.9
Iron sulphate, saturated solution, plus 1 per cent. sulphuric acid	...	...	...	2.3
Soda Bordeaux — 1 to 5 formula	...	...	...	2.6
Ammoniacal solution of copper carbonate, 1 oz. to 5 gals. water	...	...	...	1.4
Ammoniacal solution of copper carbonate, 1 pound to 25 gals. water, plus sodium carbonate, ½ pound...	...	...	...	2.
Potassium sulphide, 1 oz. to 1 gal. water	...	...	...	2.9
Copper sulphate, 1 oz. to 1 gal.—check row with winter treatment only...	...	...	...	9.3
Check	...	...	...	16.5

In nearly every test this table shows very small percentages of mildew. With the winter treatment the ammoniacal solution of copper carbonate gave the best results, 1.4 per ct. of mildewed fruit where the check row had 16.5 per ct. The other winter treatments ranged from 2 per ct. to 4 per ct. The row which received the winter treatment only, 1 oz. copper sulphate to 1 gal. water, had 9.3 per ct. of mildewed fruit. This was 7.2 per ct. less mildewed fruit than its untreated row yielded, but was considerably higher than the percentages of the other check rows.

The percentages of the tests in the first three series are particularly low, varying from .9 per ct. to 3.5 per ct. and the checks from 3.4 per ct. to 7.8 per ct. The very best was soda-Bordeaux in Series II, .9 per ct., the next lowest was ammoniacal solution of copper carbonate in Series II with 1.2 per ct. The tests with potassium sulphide gave the highest percentages in Series I and II and second highest in Series III. The results with strong ammoniacal solution of copper carbonate were very favorable, being from 1.3 per ct. to 1.8 per ct.

In the results for this one year there was no gain derived from the winter treatment. The soda-Bordeaux and copper carbonate solutions gave slightly better results than potassium sulphide did, but these differences are not great enough to be of any significance.

RECOMMENDATION.

In Bulletin 133 potassium sulphide, 1 oz. to 2 or 3 gals. water, was recommended as the best remedy. The results of three years show that it is still the best fungicide the Station has thoroughly tested. Spraying should be begun very early just as the buds are breaking and continued at intervals of about ten days.

Further testing will be necessary to determine the relative merits of soda-Bordeaux mixture and the copper carbonate solutions in comparison with potassium sulphide solutions for checking gooseberry mildew.

THE NEW YORK APPLE-TREE CANKER.*

WENDELL PADDOCK.

SUMMARY.

Attention has but recently been called to this canker of apple trees, probably because the injuries were thought to be due entirely to sun scald.

Experiments extending through two seasons prove that this canker is caused by attacks of *Sphaeropsis malorum* Pk. (see p. 355), the fungus that causes the black rot of apple, pear, and quince fruits. The experiments also indicate that this fungus occurs on a number of other plants.

This disease is widely distributed in the orchards of the State as well as in those of adjacent States. In many instances it has been very destructive.

By way of treatment it is recommended: That the trees be kept in the best growing condition; that cankered limbs be removed where practicable; that the trees be sprayed with Bordeaux mixture as recommended on page 343; and that in some instances the trunks and larger limbs be scraped and washed as recommended on page 343.

CANKER.—WHAT IS IT?

The term canker, as applied to plant diseases, has been in use in Europe for a long time, where it is commonly used to designate the injury done to trees by species of *Nectria*. (See Plate

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* Reprint of Bulletin No. 163.

XXXIII, fig. 2.) In fact the *Nectrias* have been associated with such injuries so long that in some instances the word canker has come to be regarded as a specific rather than a general term, but other species of fungi may cause a cankered condition of trees and plants. According to Hartig such wounds may be produced by the action of frost, when they are called frost cankers. In general, then, it may be said that any injury of trees, whereby a portion of the bark is destroyed and the wood laid bare may be classified under the general term, canker.

That the term canker, as applied to plant diseases, is new to many of our fruit growers may be due to the fact that the *Nectrias* are of but little economic importance in the United States.

THE NEW YORK APPLE-TREE CANKER.[1] — HISTORY.

Orchardists have been familiar with this diseased condition of the limbs of the apple tree for years. This is especially true with the Esopus Spitzenberg, where the injury to the limbs, commonly thought to be due entirely to sun-scald, has been associated with the apparent running out of this favorite apple. Attention was first called to the probability of this injury being caused by a plant disease by M. B. Waite, of the U. S. Department of Agriculture, Washington, D. C., in an article[2] that was read at the meeting of the Western New York Horticultural Society in 1898 and which appeared a few days later in the *Rural New Yorker*.[3] Mr. Waite suggested the fungus *Schizophyllum commune* Fr. as the probable cause of the disease. This article,

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[1] The name of New York Apple-Tree Canker is proposed for this disease for the purpose of distinguishing the canker produced by the attacks of the fungus *Sphæropsis malorum*, Pk. (see page 355) from cankers that are due to the action of other fungi, as the Pacific Coast Apple-Tree Canker and the European Canker.

[2] Waite. Proceedings Western N. Y. Hort. Soc., 1898, pp. 9, 10. A brief article, included in the report of the committee on botany and plant diseases, notes prevalence of an apple-tree canker in orchards of Western New York.

[3] Waite. Rural New Yorker, Feb. 5, 1898, p. 82.

together with notes[4] and a paper[5] by the writer, and a poster bulletin,[6] is the extent of the bibliography on the subject.

INVESTIGATIONS IN 1898.

In the spring of 1898 the Chapin Brothers, of East Bloomfield, N. Y., requested the Experiment Station authorities to investigate the cause of the dying of trees in their orchard. Prof. Beach visited the orchard and saw at once that a canker was the cause of the trouble, the serious nature of which was plainly evident in the numerous dead and dying trees. The writer was detailed to work on the subject, and the history of the investigations, extending through two seasons, is herewith presented.

The orchard in question originally consisted of one hundred and twenty-five acres. The trees on thirty of the eighty acres in one part were ruined by the canker and have been taken out, and the trees on one-half of the remaining fifty acres are now of little value. In the other part of the orchard originally consisting of forty-five acres, only about ten acres are left that are of much value. The owners have noticed the disease for the past six or eight years, but it has increased very rapidly in the last three or four years. They have also found that it shows a decided preference for certain varieties, the Twenty Ounce being the most susceptible; then the Baldwin, Wagener, Greening and King follow in the order named. The Tallman Sweet appears to be practically free from the disease. Trees growing in low land or in any situation where the ground was at all wet, were found to suffer

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4 Paddock. Science, 8: 596. An Apple Canker. Brief account of investigations, and concludes that the disease is probably caused by the fungus *Sphæropsis malorum*, Pk.

—— P. 836. Additional Notes on an Apple Canker. Notes the occurrence of a *Sphæropsis* on pear and quince trees, and as causing a twig blight of apple trees.

5 Paddock. Proceedings of the Western N. Y. Hort. Soc., 1899, pp. 58–64. An Apple Canker. Popular account of investigations with the disease.

6 Vermont Special Bulletin, April, 1899, gives illustrations of cankered apple-tree limbs.

most, while the trees in the outside rows were noticeably freer from the canker than those in less exposed situations.

It has been argued by some persons that the trees, now forty years old, have reached the limit of their usefulness and are dying of old age. However, those trees that are free from canker are in a very vigorous condition, and the fact that cankered limbs occur on much younger trees in widely separated localities and in the best orchards, tends to disprove this theory. Neither can the trouble in this case be attributed to neglect, unless it be in the matter of spraying, since the orchard has received from the beginning practically the same culture that is advocated by our best authorities of to-day. Sixteen years ago the orchard was thinned by taking out each alternate diagonal row of trees. The elder Mr. Chapin was one of the first to spray with insecticides, but the all important point, as it now appears, spraying with Bordeaux mixture, has been neglected. An apparent contradiction to this statement is found in an old orchard not a quarter of a mile distant, that has never been sprayed and has been in sod for years, yet there are very few cankered limbs in any of the trees. It may be mentioned, however, that this orchard is located on a different slope of land and on poorer soil. The soil of the Chapin orchard is for the most part deep and rich and has produced a vigorous growth so that now the trees are very large.

Severe and unintelligent pruning has also been given as the cause of the presence of canker in this as well as other orchards. While it is admitted that misuse of any kind may favor the development of the canker fungus indirectly, yet the answer to the specific statement is found in the fact that unpruned seedling apple trees are found in wood pastures that are badly attacked by the canker fungus.

In the preliminary studies of the canker certain large, dark colored spores were found, which were at the time supposed to come from some saprophyte; however, cultures were made from them. Agar plate cultures were also made from the diseased

bark, by taking small particles from the inner bark with sterile instruments. Two forms of fungi appeared in these cultures more or less constantly, which led to their being separated and transferred to sterilized bean stems in test tubes. Here they grew luxuriantly and soon produced fruit, the one form producing the familiar dark colored spores which were not at that time identified, while in the other the sporophores of *Schizophyllum commune* Fr. were formed.

Inoculations were made with the cultures on June 22 on seedling apple trees in the nursery row as follows: Three trees were inoculated with material from cultures of the dark spored fungus, three trees with material from cultures of *Schizophyllum commune,* and three trees were punctured but not inoculated to serve as checks. The inoculations were made by cutting a small opening in the bark with a sterilized knife and inserting a small amount of the material from the bean stem cultures between the bark and wood. All of the punctures were covered with filter paper which was kept moist for about thirty-six hours. On the same date two inoculations with each of the two cultures, together with check wounds, were made in the larger limbs of a mature apple tree. These inoculations were not moistened or protected in any way. In two weeks' time there was an area of discolored bark around each place of inoculation where the unknown fungus had been inserted. The other inoculations as well as the checks showed no signs of growth and the wounds soon healed.

As soon as it was known that the one fungus could penetrate living bark under certain conditions more inoculations were made. July 6, six young seedling apple trees in the nursery row and three limbs of a large apple tree were inoculated with the dark spored fungus, six seedling nursery trees and three limbs of a larger tree with *Schizophyllum commune,* while three seedling nursery trees and three limbs of a large tree were punctured but not inoculated to serve as checks. The inoculations made in the seedling trees were all protected with filter paper as before, but

those made in the larger tree were unprotected. The dark spored fungus grew at all points of inoculation, while all of the other wounds soon healed.

On July 11 an effort was made to imitate the scars that are found in the outer bark that are mentioned on page 339. Small pieces of the outer bark were cut from two small areas on separate limbs of a large tree which were inoculated with the dark spored fungus, making twenty-eight inoculations in all. Two similar areas were inoculated with *Schizophyllum commune* and two areas were prepared but not inoculated to serve as checks.

Ten inoculations with the dark spored fungus, two with *Schizophyllum commune* and two check wounds were made by cutting through to the wood as before. All inoculations and check wounds were kept moist with damp filter paper. The dark spored fungus grew at all points of inoculation producing deep wounds or cankers where the incisions were made through to the wood as is shown in Plate XXX, fig. 3. Fig. 1 of the same plate shows the effect of the inoculations where small pieces of the outer bark were removed. The fungus was unable to penetrate to the cambium and made only small surface wounds, as may be seen in the illustration. The pieces of bark have been removed on one side leaving scars which resemble those that occur on cankered limbs as in Plate XXX, fig. 2.

On the same date, July 11, four inoculations were made with each of the two cultures in the larger limbs of a pear tree and four of each in the larger limbs of a quince tree. The inoculations, together with check wounds, were kept moist with damp filter paper as before. The dark spored fungus grew at all points of inoculation on the pear tree, but did not grow on the quince. All of the inoculations with *Schizophyllum commune* together with check wounds soon healed.

These experiments showed conclusively that the dark spored fungus can penetrate living apple-tree bark under certain conditions and produce a cankered condition of apple-tree limbs and also indicated that it may produce a diseased condition of pear-tree bark.

On the other hand it is evident that *Schizophyllum commune* Fr. cannot penetrate living apple-tree bark and it is quite probable that the same is true of pear-tree bark. The result of the inoculations on the quince cannot be regarded as conclusive because of the small number of inoculations made; but numerous inoculations made in the spring of 1899 showed that the dark spored fungus can produce a cankered condition of quince limbs when inserted under the bark.

The stress of other duties during the growing season prevented any study into the nature of the canker fungus and nothing further was done until fall when cultures of the fungus were shown to Mr. F. C. Stewart, the Station Botanist. He at once noted a strong resemblance of the dark spores to those of the black rot of the apple, *Sphaeropsis malorum* Pk., and suggested that it might be that disease. Mature apples were at once inoculated with material from the test tube cultures that had been obtained from cankered apple-tree limbs. In twenty-four hours decay had begun around the points of inoculation and in sixteen days pycnidia and mature spores of *Sphaeropsis* were found on all inoculated apples. The check apples which were punctured but not inoculated and kept under the same conditions remained sound. This experiment was repeated many times and the results were always the same.

Now that it was known what to look for an examination of cankered limbs in the orchard revealed the presence of an abundance of small, dark, fungus pustules or pycnidia on the brown and shrunken areas of dead bark. Fig. 3 of Plate XXVIII is a larger view of the smaller canker shown in Fig 1 at *b*. An examination of the bark on the older portion of the cankered area reveals the presence of numerous pycnidia in which the dark colored spores, that have been frequently mentioned, are borne. They are shown natural size in Fig. 4, which is a small section of the dead bark from the same canker. It will be seen that the pycnidia are abundant and large enough to be easily found.

Pycnidia containing mature spores were also found to be abundant on the dead bark surrounding the points of inoculation that were made from the cultures of *Sphaeropsis*. Plate XXX, fig. 3, is from a photograph of one of the limbs of an apple tree as it appeared at the close of the present season, that was inoculated in the spring of 1898 with cultures made from a cankered limb. Pycnidia are numerous on the surface of the bark and on the decorticated wood as well.

The result of over fifty inoculations made from cultures that were obtained from cankered apple-tree limbs prove that the apple-tree canker of New York apple orchards is caused by a fungus of the genus *Sphaeropsis*. In every instance where the incisions were made through to the wood, typical cankers were produced and mature fruit of the *Sphaeropsis* formed on the decaying bark and in some instances on the decorticated wood also. The inoculation experiments were repeated many times during the season of 1899 and the results have been the same.

GEOGRAPHICAL DISTRIBUTION.

A personal examination of a great many orchards during the past two seasons reveals the fact that this canker of apple trees is widely distributed in the orchards of New York. In fact an orchard is rarely seen that is entirely free from the disease. As is to be expected, however, it is more abundant in some localities than in others, and as has been previously mentioned, some varieties are more subject to the disease than others. It is specially injurious in many of the apple growing sections of western New York.

Responses to a circular letter sent to the authorities of the various experiment stations, together with personal examinations, bring out the positive information that this canker occurs in Connecticut, Indiana, Maryland, Michigan, Pennsylvania and Vermont, and that it probably occurs in Illinois, Maine, Massachusetts, Minnesota, New Jersey, West Virginia and portions of Canada. It seems probable that when the disease becomes more

generally known it will be found in many of the apple growing sections of the northern, central, and New England states.

APPEARANCE OF CANKERED LIMBS.

When one approaches a diseased tree his attention will be attracted to the dark and enlarged sections of the larger limbs. A closer examination shows that the bark is much roughened as well as thickened, and in many instances a portion of the wood is laid bare. The decaying bark and wood offer a convenient lodging place for borers and fungi which aggravate the injury and add to its unsightly appearance. The dead bark on many of the diseased limbs clings tenaciously to the decaying wood, which is a feature that distinguishes this canker from sun scald, since with the latter trouble usually the first symptom to be noticed is the peeling of the bark from the injured surface. The area of bare wood is often small as compared to the extent of swollen bark; limbs are frequently seen that for six feet or more of their length are covered with rough bark. The progress of the disease on such limbs may be marked by numerous pits or scars, showing where the fungus was able to live until perchance it gained entrance to the cambium through some injury, when a serious wound was the result. These scars are usually circular in form and may be outlined by two or more concentric lines. An example of this form of the disease is shown in Fig. 1 of Plate XXIX, where for more than six feet of its length the limb is covered with the rough bark or the scars where the bark has become detached. The fungus has only reached the cambium and formed a canker at *a*. Fig. 2 of Plate XXX is a larger view of a section of the same limb showing the scars more in detail.

Other instances occur, where, though the bark is much swollen and roughened, the fungus has not been able to penetrate to the cambium, but has died after a time leaving the scars of its attack, aside from which the limb has regained its normal condition.

The fungus shows a preference for the larger limbs of mature trees. Small limbs and young trees are much less frequently

attacked, though the trunks and branches of the latter are sometimes badly injured, and twigs of the current season's growth may suffer serious injury from attacks of the fungus. Twenty Ounce apple trees are apparently the exception, since in some localities the trunks of this variety are badly injured. The fungus extends down from diseased branches or from canker spots at the forks of the tree till in aggravated cases large areas of bark are destroyed exposing the wood in ugly wounds. These patches of black, decaying wood are conspicuous from a distance. Old age and neglect, or a lack of vigor from any cause evidently favor the disease though apparently thrifty trees are frequently ruined by its attack.

The effect of a canker on a limb depends on the amount of bark that is injured or destroyed. In severe cases the disease may extend entirely around a limb, thus effectually girdling it. Thus it occasionally happens that the leaves on some part of a tree shrivel and die without apparent cause, but a close examination shows the presence of rough, dead bark somewhere on the limb, indicating the presence of the canker fungus which has extended around the limb and cut off the flow of sap.

Plates XXVIII and XXIX are reproduced from photographs of typical cankered limbs. In Fig. 1 of Plate XXVIII the characteristic rough bark is shown and at *a* the wood is exposed, the white fruiting bodies of the fungus, *Schizophyllum commune* Fr., being conspicuous on the dead bark. At *b* is a canker spot of comparatively recent formation. Fig. 2 shows the same limb from which the dead bark has been removed; only a narrow strip of live bark remained that kept the limb alive. Fig. 3 is an enlarged view of the more recent canker shown in Fig. 1 at *b*. This canker is evidently of three seasons' growth as is indicated by the three series of concentric lines, now rather indistinct, that at one time separated the dead from the living bark. The extent of the current season's growth can be readily distinguished by the smoother appearance, while a distinct line separates the dead from the living bark.

In some instances cankers occur quite uniformly on the southwest side of the trees, thus indicating that they had their origin in injuries produced by sun scald. The work of the fungus may be recognized by the thick rough bark, while the fruiting pustules reveal its presence where it is still or has recently been in an active condition.

EXTENT OF INJURY.

The extent of the injury done to the orchards of the State can scarcely be estimated, but it is safe to say that this canker is one of the worst diseases with which the orchardist will have to contend since it attacks the tree directly instead of the foliage and fruit as is the case with the majority of our orchard diseases. The appearance of the cankers is such that their injurious nature may not be apparent to the casual observer until his attention is attracted by the shrivelling of the leaves; thus the tree may be ruined before it is realized that anything serious is the matter. In one instance the loss of a large acreage of orchard was due to the attacks of the canker fungus (see page 333) and in a great many orchards it has done serious damage.

TIME AND MANNER OF INFECTION.

Infection takes place in the spring of the year as is shown by the growth that the fungus makes in the bark. The presence of the fungus in a newly infected limb is first indicated by a small area of discolored bark. This area extends slowly as the fungus grows outward in all directions till mid-summer, when a definite boundary forms between the dead and living bark, thus showing that growth for the season has stopped. This season's growth had stopped by the first of August, and in some instances pycnidia containing mature spores were found at that time on bark where infection had taken place in the spring.

Many of the spores remain in the pycnidia till the following spring, or longer, when they are given off and disseminated. The mycelium is unable to penetrate to the cambium through living

bark, but those spores that chance to fall and germinate in a wound, produce the cankers. Other spores are deposited on limbs that have an abundance of dead and decaying outer bark where they find conditions suitable for growth. In such instances no direct injury is done to the tree, but spores are produced and disseminated so that a constant source of infection is maintained. The spores possess great vitality since some of them germinate after having been kept a year in the laboratory.

In some instances the mycelium apparently lives over winter and continues its growth the following spring. The formation of the largest cankers can scarcely be explained in any other way. However, in all of the inoculations made in the spring of 1898, in only one instance did the resulting canker enlarge any during the present season. See Plate XXX, fig. 3.

DOES THE MYCELIUM PENETRATE THE WOOD?

This question is suggested by the presence of two or more cankers on the same limb, the external appearance of the more recent ones suggesting the possibility of the fungus having passed from the old canker through the wood and appearing on the surface of the limb at favorable points where the newer cankers were formed. An examination of a number of specimens and the occurrence of pycnidia on decorticated wood shows that while the mycelium does penetrate the wood to some extent, the fact is of little economic importance. One limb was examined that had five small cankers on it at intervals of about a foot. On splitting the limb it was found that the mycelium had penetrated the wood at but one point and that for only a short distance.

PREVENTIVE MEASURES.

Although experiments in treating this disease are under way no results have yet been reached and from the nature of the fungus it will be seen that a number of years must elapse before data

can be secured from which definite conclusions may be drawn. However it is a matter of common observation that in the majority of instances the disease is not nearly as prevalent in orchards that have been well sprayed with Bordeaux mixture for several years past as it is in those that have not been sprayed. Judging from the success with which many other plant diseases are combated it is reasonable to expect beneficial results to follow systematic spraying with Bordeaux mixture as a preventive of the canker.

In localities where canker is abundant special attention should be paid to the sanitary condition of the trees. Perhaps one of the most important considerations is to see that the trees are not crowded and that they are pruned so as to admit sunshine and a free circulation of air. The old bark is not shed as freely from the limbs and trunks of trees that are densely shaded and the moisture collecting in this bark is not easily dried out; thus faculative parasites like the canker fungus as well as saprophytic fungi find congenial surroundings.

The practice of scraping and whitewashing the trunks and branches of fruit trees has largely fallen into disfavor, but it is certainly a commendable practice and should be adopted in localities where canker is severe. However, washes that are less conspicuous and equally, if not more effective, than whitewash are now recommended; the following formula has been satisfactory to some orchardists:

WASH FOR TREE TRUNKS.

Whale oil soap	1 pint.
Slaked lime	3 pints.
Water.	4 gallons.
Wood ashes	To thicken as desired.

Dissolve the soap in hot water, then stir in the lime. When the ingredients have been reduced to a smooth state by stirring dilute with water to four gallons, then stir in wood ashes till the wash is of the desired consistency.

Other formulæ equally as good as the one given are in use, but

the important ingredients in most of them are the same as in the one given above.

These washes probably have the effect of softening and loosening the old bark so that it is more readily shed, thus relieving the bark bound condition and inducing a vigorous growth. Bordeaux mixture is beneficial in this respect as a smooth, shiny appearance of the bark is a characteristic of well sprayed trees.

A discussion of the necessity of thorough cultivation and fertilization of orchards need not be entered into here, but it may be said that any treatment that tends to promote the vigor of the trees indirectly gives them greater power to resist disease. This fact was strikingly illustrated in the inoculation experiments with nursery stock where it was found that the trees that were making a feeble growth were far more susceptible to the action of the fungus than those which were making a vigorous growth.

Usually but little attention is given to slight wounds that are made here and there on the trees, but it should be remembered that a majority of cankers start from some mechanical injury. Too much care cannot be exercised not to wound or bruise the limbs when trimming the trees or picking the fruit. Wounds are frequently made by the chafing of ladders against the limbs or by the workman's boot when climbing through the trees. Serious wounds are also frequently made by propping the limbs when they are overloaded with fruit. The props should be padded or have the corners rounded where they come in contact with the limbs; they should be put in place carefully and not be driven under the limbs as is sometimes done. All wounds, whether accidental or made in trimming, should be protected with thick paint or grafting wax.

Cankered limbs should be cut out wherever practicable, or in some cases it may pay to cut off the diseased bark and cover the wounds as recommended above. Then as a preventive measure we feel warranted in recommending thorough spraying with Bordeaux mixture, giving the first treatment before the leaf-buds

open in the spring, followed by the three sprayings that are usually given the trees for apple scab. Great pains should be taken to see that the limbs are thoroughly protected with the mixture as well as the foliage and fruit. The approximate dates of spraying may be given as follows: 1. About the time the leaf-buds begin to open. 2. About a week before the blossom-buds open. 3. As soon as all of the blossoms have fallen. 4. Ten days or two weeks after No. 3.

INVESTIGATIONS IN 1899.

It was originally planned that this season's work should be a verification of the previous year's results, namely, the identification of the canker fungus and the determination of its relation to what was thought to be the same species that occurs on pear and quince trees and on the fruit of all three species of trees. But the work broadened as *Sphaeropses* were found on a variety of hosts representing seven orders of plants.

Since a knowledge of the host plants of any plant disease is of great practical value in order that it may be successfully combated, an attempt was made to determine the relation of the species of *Sphaeropsis,* represented by the different hosts, to the canker fungus.

In the spring of 1898 specimens of blighted apple-tree twigs were received from Odessa, N. Y. It was not determined at the time what was the cause of the blight, but a subsequent examination revealed the presence of numerous pycnidia containing mature spores of a *Sphaeropsis.* On visiting the orchard late in the fall, it was found that the twig blight had been quite noticeable in 1897, but there was none to be found on the current season's growth. In all cases noticed, when once attacked, the entire growth of the season had been killed and in a few instances the disease had extended into the previous season's growth. There were a few miniature canker spots on the smaller limbs but none were noticed on the larger branches and the trees were in fairly vigorous condition.

Some pear trees growing in a door-yard about twenty-five rods distant from the orchard were pointed out as being in a dying condition, the top of one tree having been entirely destroyed while the other trees were half or two-thirds dead. The pycnidia of a *Sphaeropsis* were found to be very abundant on the dead bark, while a few black, shriveled pears that were still attached to the branches were attacked by the black rot fungus, *Sphaeropsis malorum* Pk.

A *Sphaeropsis* was also found on the twigs of a quince tree that grew by the side of the pear tree.

At a later date a canker was found on a quince tree in the Station orchards. The appearance of the cankers and their effect on the limbs was much the same as the canker of apple tree limbs, the swollen sections of limbs and the roughened bark at once attracting attention. The pycnidia of a *Sphaeropsis* were abundant on the dead bark where the fungus had recently been in an active condition. This fungus was also found to be abundant in the large quince orchard of Maxwell Brothers, near Geneva. There were but few typical cankers on these trees, but in many instances there was a well defined longitudinal strip of dead bark on the limbs on which pycnidia of a *Sphaeropsis* were abundant. It seems probable, however, that in such instances, as well as with the pear trees mentioned above, the fungus was following, but aggravating, former injuries.

Dilution plate cultures were made of the *Sphaeropses* from the twigs of the three different host plants and after the fungus had fruited, fruits of the apple, pear and quince were inoculated with pure cultures of the fungus from each of the three hosts. The fruits were kept in closed glass jars, the check fruits punctured but not inoculated occupying jars by themselves. Black rot, *Sphaeropsis malorum* Pk., was produced in each inoculated fruit while the checks remained sound. Usually there would be an area of decayed tissue around the points of inoculation in twenty-four hours, depending on the degree of ripeness of the

fruit. The decay progresses rapidly in the ripe fruit; in some instances the greater portion of the surface became brown, and mature spores of the fungus were formed in six days.

In the spring of 1899 a *Sphaeropsis* was found on dead and dying Japanese plum trees at Riverhead, N. Y. Cultures were made of the fungus, and apple, pear, and quince fruits were inoculated. Black rot was again produced in the inoculated fruit while the check fruits remained sound.

These results led to an investigation of the local distribution of the genus *Sphaeropsis,* when it was found to be widely distributed; as the list of host plants given in Tables I and II will show. Cultures were made of the *Sphaeropses* from each host and apple, pear, and quince fruits were inoculated with cultures from each so far as the supply of fruit would permit. Three fruits at least, and in a majority of instances six, were inoculated with cultures from each host. Black rot was readily produced in the fruits, there being apparently no difference in the effect of the *Sphaeropses* as obtained from the different hosts. The inoculated fruits as well as the checks were kept in closed glass pars, as before.

During the progress of the work it was noticed that in most cases there was but little difference in the average size of the spores as they occurred on the different hosts. It was also found that when apple, pear, or quince fruits were inoculated with cultures of *Sphaeropsis* from these hosts the resulting spores were larger and of the size of those found on fruits attacked by black rot. The series of spore measurements given in the table below was made to show the relation of the average size of the spores to the host on which they are grown. Since spores of *Sphaeropsis* as they occur on any host vary greatly in size, even in the same pycnidium, an average of fifty measurements was taken in each instance.

Table I gives: (1) A list of hosts from which cultures of *Sphaeropsis* were made; (2) average length of 50 spores as they occur on the hosts; (3) average length of 50 spores as they occur

on apple, pear, and quince fruits when inoculated with cultures of *Sphaeropsis* from the different hosts.

TABLE I.— SPORE MEASUREMENTS OF SPHÆROPSES FROM DIFFERENT SOURCES AND ON DIFFERENT HOSTS.

Hosts from which cultures of Sphæropsis were obtained.	Average length of 50 spores as they occur on the host.	Average length of 50 spores produced on apple fruits inoculated with material from the different hosts.	Average length of 50 spores produced on quince fruits inoculated with material from the different hos s.	Average length of 50 spores produced on pear fruits inoculated with material from the different hosts.
Pear tree twigs	22	30	29	26
Quince tree limbs	23	29	29	27
Apple tree limbs	26	29	30	28
Japanese plum, Prunus triflora, Roxb.	28	30	30	30
Hawthorn, Cratægus oxyacantha, L.	21	28	..	..
Persimmon, Diospyros virginiana, L.	21	28	..	..
Wild crab, Pyrus coronaria, L.	21	28	..	..
Sumach, Rhus typhina, L.	23	29	..	..
Bitter sweet, Celastrus scandens, L.	22	..	..	..
Apricot, Prunus armeniaca, L.	22	30	..	..
Choke cherry, Prunus virginiana, L.	21	29	..	..
Hop horn beam, Ostrya virginica, Willd., decorticated wood	22	28	..	..
Mulberry, Morus alba, L.	21	..	..	..
European plum, Prunus domestica, L.	21	25	..	..
Elder, Sambucus canadensis, L.	21	29	..	..
Pear leaves	24	30	..	..

The table is of interest in that it shows that the average size of spores of *Sphaeropsis* varies according to the host on which they are grown. For instance the pycnidia and spores as they grow on pear wood are somewhat smaller than those that are found on apple wood, yet the spores produced on apple fruits inoculated with cultures from either host, are of the same size and character; similarly, though not shown in the table, when pear trees are inoculated with cultures of *Sphaeropsis* taken from apple trees the resulting pycnidia and spores are of the average size of those found in nature on pear tree bark.

The spore measurements also show that in most cases there is but little difference in the average size of the spores of *Sphaeropses*

as they occur on the hosts under consideration. Those on apple and Japanese plum trees are the only ones where the average length is noticeably greater than the rest in the list. Cultures of *Sphaeropsis* from either apple or Japanese plum trees when inoculated into apple, pear, or quince fruits produce black rot and as is shown in Table II these cultures grow interchangeably on at least four species of trees. In each instance the fruiting bodies resulting from the cross inoculations have the same characters as those that occur on the trees naturally.

Since cultures of *Sphaeropses* from the different hosts produce black rot of fruit, one apparently as readily as another, it was to be expected that the different cultures would make similar growths when cross inoculations were made in the trees. Accordingly, apple, pear, plum, cherry, and quince nursery trees were planted in a plat on the Station grounds for inoculation experiments.

Dilution plate cultures were made of the *Sphaeropses* from the different hosts and after spores formed, transfers were made to sterilized bean stems in test tubes. The inoculations were made by making a small incision in the bark with a flamed knife and inserting some of the pure cultures of the fungus from the test tubes between the bark and wood; then the wounds were covered with grafting wax. The work was done the last of May and first of June.

Table II gives the plan of the experiment together with the results; and shows: (1) Kind and number of trees inoculated and number of inoculations made in each tree; (2) source of cultures with which inoculations were made; (3) growth of fungus where inoculated.

TABLE II.—GROWTH OF SPHÆROPSIS FROM DIFFERENT SOURCES ON DIFFERENT HOSTS.

Hosts from which cultures of Sphæropsis were obtained.	Apple Trees.		Pear Trees.		* Plum Trees.		Cherry Trees.		Quince Trees.	
	Each figure represents number of inoculations made in one tree.	Growth of fungus.	Each figure represents number of inoculations made in one tree.	Growth of fungus.	Each figure represents number of inoculations made in one tree.	Growth of fungus.	Each figure represents number of inoculations made in one tree.	Growth of fungus.	Each figure represents number of inoculations made in one tree.	Growth of fungus.
	6	Fair	5	Slight	4	Tree died	None of these inoculations successful.	..	4	Good.
	5	Slight	5	Slight	4	Very good		..	4	Slight.
Pear tree twigs	4	Slight	5	Good	4	Slight		..	4	Slight.
	4	Slight	5	Very good	4	Slight		..	4	Fair.
Check	4	0	4	0	4	0		..	4	0
	4	Slight	4	Fair	4	Slight		..	4	Good.
	4	Fair	4	Good	4	Slight		..	4	Slight.
Quince tree limbs	4	Fair	4	Good	..	..		..	4	Fair.
	4	Slight	4	Good	..	..		..	4	Good.
Check	4	0	4	0	..	..		..	4	0
	4	Fair	4	Fair	..	Fair		..	4	Fair.
Black rot of pear, Sphæropsis malorum, Pk.	4	Fair	4	Very good	4	Fair		..	4	Fair.
	4	Fair	4	Slight	4	..		..	4	Fair.
	4	Fair	4	Slight	..	..		..	4	Fair.
	4	Very good	4	Very good	..	Good		..	4	Fair.
	4	Very good	4	Very good	4	Good		..	4	Good.
Apple tree limbs	4	Very good	4	Very good	4	..		..	4	Good.
	4	Very good	4	Very good	..	..		..	4	Fair.

Check	4	0	4	0	4	0	None of these inoculations successful.	....	4	0
Japanese plum, Prunus triflora, Roxb.	4	Very good	4	Very good	4	Good		....	..	
	4	Very good	4	Fair	4	Slight		....	..	
Hawthorn, Cratægus oxyacantha, L.	4	Fair	4	Fair	4	Very good		....	..	
	4	Fair	4	Fair	..	....		....	..	
Persimmon, Diospyros virginiana, L.	4	Slight	4	Slight	4	0		....	..	
	4	Slight	4	Slight	4	0		....	..	
Wild crab, Pyrus coronaria, L.	4	Fair	4	Good	4	0		....	..	
	4	Fair	4	Fair	4	0		....	..	
Check	4	0	4	0	4	0		....	..	
Sumach, Rhus typhina, L.	4	Fair	4	Fair	4	0		....	6	0
	4	Fair	4	Fair	4	0		....	..	
Bitter-sweet, Celastrus scandens, L.	4	Fair	4	Fair	4	0		....	..	
	4	Fair	4	Very good	4	0		....	..	
Apricot, Prunus armeniaca, L.	4	Fair	4	Slight	4	Tree died		....	..	
	4	Fair	4	Slight	4	Fair		....	..	
Check	4	0	4	....	..	....		....	..	
Choke cherry, Prunus virginiana, L.	4	Good	4	Fair	4	Fair		....	..	
	4	Good	4	Fair	4	Tree died		....	..	
Hop hornbeam, Ostrya virginica, Willd., decorticated wood	4	Good	..	....	4	Very good		....	..	
	4	Good	..	....	4	Very good		....	..	

TABLE II — *Concluded.*

Hosts from which cultures of Sphæropsis were obtained.	Apple Trees.		Pear Trees.		* Plum Trees.		Cherry Trees.		Quince Trees.	
	Each figure represents number of inoculations made in one tree.	Growth of fungus.	Each figure represents number of inoculations made in one tree.	Growth of fungus.	Each figure represents number of inocula ions made in one tree.	Growth of fungus.	Each figure represents number of inoculations made in one tree.	Growth of fungus.	Each figure represents number of inoculations made in one tree.	Growth of fungus.
Mulberry, Morus alba, L.	4	Fair........	..	....	4	Good	None of these inoculations successful.	....	..	
	4	Fair........	..	....	4	Very good		....	..	
European plum, Prunus domestica, **L.**	4	Very good...	..	....	4	0		....	..	
	4	Very good...	..	....	4	0		....	..	
	4	0	..	....	..	....		....	..	
Elder, Sambucus canadensis, L.......	4	0	..	....	..	....		....	..	
	4	0	..	....	..	....		....	..	
	4	0	..	....	..	....		....	..	

* **Part** European and part Japanese plum trees **were** used in the experiment; the inoculations were successful on the Japanese tree **only.**

The extent of growth of the *Sphaeropses* where inoculated has been expressed in the relative terms, slight, fair, good and very good. Figures 1, 2 and 3 of Plate XXXI are reproduced from a photograph of inoculated nursery trees of apple, pear and Japanese plum respectively, and show what has been termed a very good growth. Figure 4 of Plate XXXI shows a slight growth on an apple tree, while Fig. 5 is a check apple tree. The other two degrees of growth range between the two shown in the illustration.

Where the fungus made a very good growth it spread rapidly till the different inoculations coalesced and formed continuous cankers as is shown in the illustration. In some instances pycnidia formed by the tenth of July and by the first of August growth had stopped as could be seen by the formation of a definite boundary between the dead and living bark. Pycnidia were now abundant on the dead bark and occasionally on the decorticated wood under the grafting wax as well as elsewhere on the dead surface. In some instances where the fungus made a less vigorous growth the area of dead bark was entirely covered with the wax.

A number of the different cultures were inoculated into all four kinds of trees, all but three into both apple and pear trees, while all were inoculated into apple trees. Twenty-five sweet and twenty-five sour cherry trees, and twenty-five European plum trees were also used in the experiment, but none of the inoculations on these trees were effective. In all of the other inoculations there were but two entire failures. But the inoculations made with cultures of *Sphaeropsis* from cankered apple tree limbs made a greater growth than most of the others. Those made with cultures obtained from Japanese plum were the only ones which made a comparable growth.

The results of the inoculations on the pear trees are interesting from the fact that the cultures obtained from cankered apple tree

limbs made a greater growth when inoculated into pear trees than the cultures did that were made from diseased pear trees.

Various other inoculations were made that are not given in the table, the details of which need not be entered into here; it may be said, however, that of something over 1,000 inoculations made in 1899 very few gave negative results. Fig. 1 of Plate V shows an apple tree whose top is dead, the result of inoculations made with cultures of *Sphaeropsis* obtained from sumach. It should be pointed out, however, that this particular branch was making a feeble growth, and that inoculations made in two of the side branches failed to grow. In several other instances where inoculations were made in weak trees the fungus made a much greater growth than it did in adjacent vigorous trees. This point is of great practical importance and confirms what has been said on this subject on a former page. Fig. 2 of Plate XXXII shows a twig blight of pear and apple trees respectively, the result of inoculations made with cultures of *Sphaeropsis* from cankered apple tree limbs in twigs of the current season's growth.

The results of the inoculation experiments tend to show that the number of species of *Sphaeropsis* can be materially reduced. In some instances it appears that a new host has served as a basis for making a species, and since many of the hosts given in the table represent different species it would seem that this plan had been followed when some of these species were made. So far as the writer can determine there is but slight difference in the morphological characters of the species that are represented in the tables by the different hosts, such as might occur with any fungus when grown on different media or when transferred from one plant to another. Neither do the published descriptions of these species suggest any material differences.

A set of the *Sphaeropses* on the different hosts was submitted to Mr. J. B. Ellis, Newfield, N. J., for identification with the published descriptions. His determination of the species so far as he was able from the specimens sent are given in Table III.

TABLE III.— PRESENT CLASSIFICATION OF SPHÆROPSIS FOUND ON DIFFERENT HOSTS.

Pear tree twigs	Sphæropsis sp. Apparently same as on plum.
Quince tree limbs	Sphæropsis cydoniæ, C. and E.
Black rot of apple, pear, and quince fruits	Sphæropsis malorum, Pk.
Apple tree, bark	Sphæropsis mali (West.), Sacc.
Apple tree, decorticated wood	Sphæropsis cinerea (C. and E.), Sacc.
Japanese plum, Prunus triflora	Sphæropsis sp.
Hawthorn, Cratægus oxyacantha, L.	Sphæropsis demersa (Bon.), Sacc.
Persimmon, Diospyros virginiana, L.	Sphæropsis sp.
Wild crab, Pyrus coronaria, L.	Sphæropsis — New sp?
Sumach, Rhus typhina, L.	Sphæropsis sumachi (Schw.), C. and E.
Bitter sweet, Celastrus scandens, L.	Sphæropsis celastrina, Pk.
Apricot, Prunus armenica, L.	Apparently same as on plum.
Choke cherry, Prunus virginiana L.	Sphæropsis cerasina, Pk.
Hop hornbeam, Ostrya virginica, Willd. (decorticated wood)	Sphæropsis sp.
Mulberry, Morus alba, L.	Sphæropsis mori, Berlese.
European plum, Prunus domestica, L.	Same as on Japanese plum.
Elder, Sambucus canadensis, L.	Sphæropsis sambuci, Pk.
Pear leaves	Sphæropsis mali, West., foliicolous form.

A discussion of the relation of these species will be out of place at this time. However it may be pointed out that the inoculation experiments prove that the species occurring on apple-tree bark, *S. mali,* and on decorticated apple-tree wood, *S. cinerea,* are the same; also that these species are identical with the black rot fungus, *S. malorum.* Thus it will be seen that some interesting questions in nomenclature are involved. Which of these names should stand, if either, or whether they will all prove to be synonyms can only be determined after a careful study of the entire genus is made.

In former papers by the writer referred to on page 333 mention was made of the fungus, *Sphaeropsis malorum* Pk., as being the probable cause of the New York apple-tree canker. It is therefore suggested that this name be retained for the present in order that still further confusion in nomenclature may be avoided.

BODY BLIGHT OF PEAR TREES.

In the spring of 1898 when the preliminary studies with apple canker were begun a few inoculations were made in the larger

limbs of a pear tree with cultures of *Sphaeropsis* obtained from cankered apple-tree limbs. The details of the experiment are given on page 336. The fungus grew readily at all points of inoculation and though the culture material was inserted between the bark and wood it did not attack the cambium layer, but made its growth in the outer bark. Here dead sunken areas were produced similar to those that are so common on the trunks and larger limbs of pear trees. These definitely outlined and sunken areas of dead bark commonly known as body blight, have long been thought to be due to the action of the pear blight bacillus; however, there seems to be no definite reason for such belief.

But little attention was given the matter at the time since it was not then known that *Sphaeropsis* occurred on these blighted areas. In the spring of the present year, however, a *Sphaeropsis* was found to be comparatively abundant on the diseased bark of pear trees in the Station orchards. Since that time a large number of pear trees from many localities affected with body blight have been examined and in nearly every instance a *Sphaeropsis* was present though not in sufficient quantity to account for many of the blighted areas. *Macrophoma malorum* (Berk.) Berl. et Vogl. is commonly present in large quantities on the dead bark and since *Sphaeropsis* is able to produce body blight may not this closely related fungus be an important factor in producing the diseased condition?

Fifty successful inoculations made this spring with cultures of *Sphaeropsis* in mature pear trees confirm last year's results. An attempt was also made to grow the *Macrophoma* artificially, but it made an indifferent growth on all of the media that were tried and produced no fruit, consequently inoculation experiments with this fungus could not be undertaken at that time.

THE PACIFIC COAST APPLE-TREE CANKER.

After the publication of the paper, An Apple Canker, the writer received inquiries concerning the canker from the secretaries of

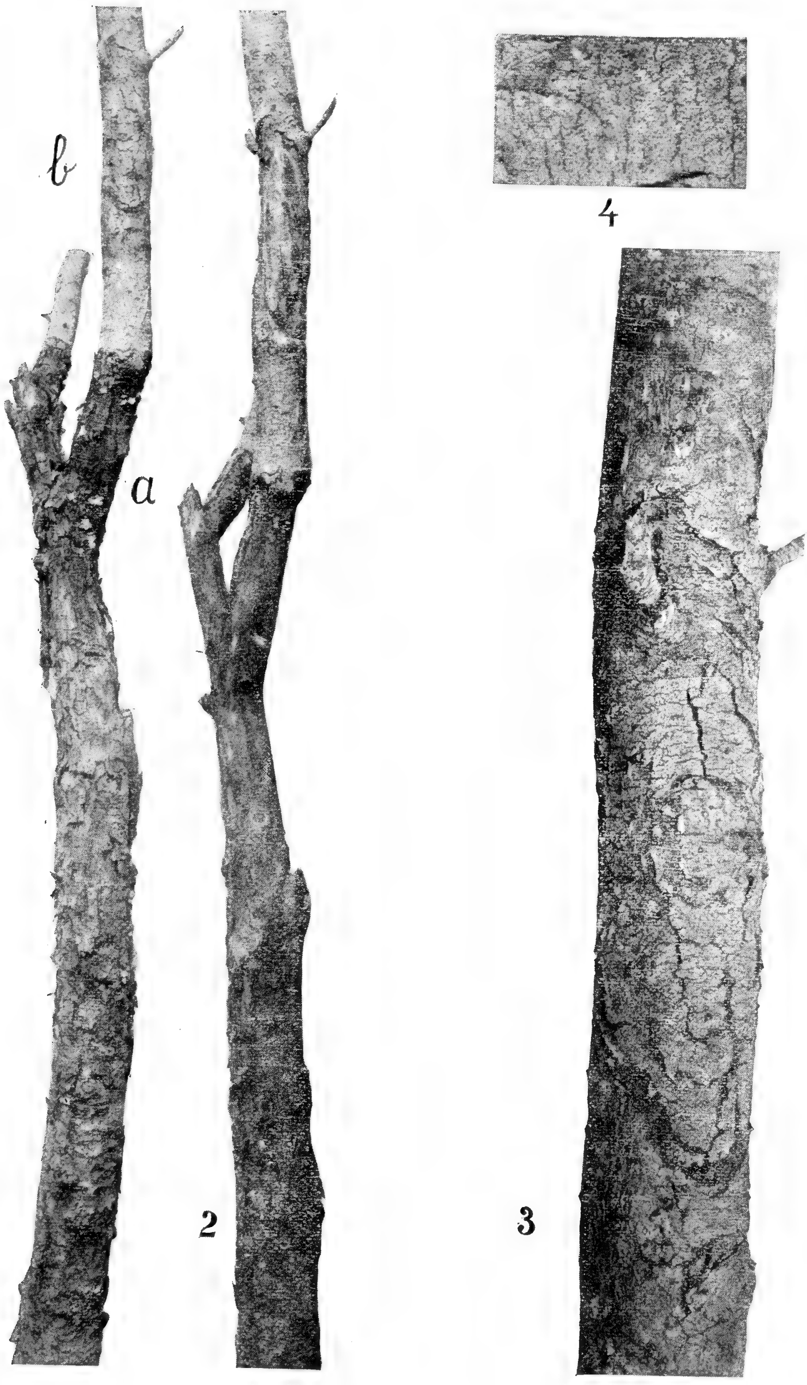

PLATE XXVIII.

PLATE XXIX.

horticulture respectively of Oregon, Washington and British Columbia. These gentlemen sent specimens of diseased limbs which upon examination were found to be attacked by an entirely different fungus from the one that causes the New York canker, the spores were small, curved and hyaline while the spores of *Sphaeropsis* are large, oval and dark brown in color. A liberal number of specimens were received from each of the three sections and the fungus was the same in each case and so much in evidence that there can be little doubt but that it is the cause of the Pacific coast canker. Some of the specimens were submitted to Prof. C. H. Peck, State botanist, who pronounced the fungus to be a new species of *Macrophoma.* This disease because of its destructive nature has attracted a great deal of attention for a number of years in the Pacific Coast States, but no satisfactory method of combating it has yet been found. Since entirely different climatic conditions obtain in that part of the country it is not likely that the line of treatment recommended for combating the New York apple canker will be effective against this disease as it occurs on the Pacific coast.

Fig. 1 of Plate XXXIII is from a photograph of an apple-tree limb showing a typical specimen of the Pacific coast apple-tree canker.

THE EUROPEAN CANKER.

Fig. 2 of Plate XXXIII shows a canker on a quince tree limb which was produced by the fungus, *Nectria cinnabarina* (Tode.) Fr. This shows what is known as the tubercularial or conidial stage of the fungus; what appear as small white bodies in the picture scattered over the surface of the dead bark, are brilliant red or cinnabar colored stromata which bear the conidia or fruiting bodies of one stage in the life history of the fungus. It will be seen that the comparatively large size and brilliant color of the stromata render the fungus conspicuous so that it is not easily mistaken.

Another species, *N. ditissima,* is the common canker-producing fungus of the orchard trees in many parts of Europe. Neither of the species is sufficiently abundant in the orchards of the United States to be regarded as a pest.

The illustration in Plate XXXIII, fig. 2, is from a photograph of one of a few quince tree limbs attacked by *N. cinnabarina* that were found in the quince orchard of T. C. Maxwell and Brothers, Geneva, N. Y.

ACKNOWLEDGMENTS.

It is with pleasure that I acknowledge my indebtedness to Prof. Beach, at whose earnest request this work was undertaken, and to whose kind consideration its completion was made possible. To Dr. Thaxter I am indebted for advice on the question of nomenclature and to Mr. Ellis for the determination of species.

EXPLANATION OF PLATES.

PLATE XXVIII. Fig. 1.—*A cankered apple tree limb, wood exposed at* a *and white fruiting bodies of* Schizophyllum commune *Fr. are conspicuous on the dead bark. A canker of more recent formation is shown at* b.

Fig. 2.—*The same limb as in Fig.* 1 *with the dead bark removed.*

Fig. 3.—*A larger view of the small canker shown at* b. *The surface is thickly dotted with pycnidia.*

Fig. 4.—*Small section of dead bark from canker in Fig.* 3 *showing pycnidia natural size.*

PLATE XXIX.—*Different forms of cankers. Fig.* 1 *shows limb that for more than six feet is covered with rough bark, or scars where bark has become detached; fungus has reached cambium at* a.

2

3

1

PLATE XXX.

PLATE XXXI.

PLATE XXX. Fig. 1.—*Apple tree bark inoculated with cultures of* Sphæropsis *from cankered apple limbs. Inoculations were made in the outer bark; the fungus was unable to reach cambium but made small wounds in the outer bark. Where the bark has been removed the scars resemble those shown in Fig.* 2.

Fig. 2.—*Section of limb shown in Plate XXIX, Fig.* 1, *enlarged to show scars more in detail.*

Fig. 3.—*Limb of a large apple-tree inoculated in spring of* 1898 *with culture of* Sphæropsis *from cankered apple tree limb. Photographed fall of* 1899. *The canker enlarged materially during the present season. Pycnidia of* Sphæropsis *are abundant on dead bark and decorticated wood.*

PLATE XXXI.—*Inoculation experiments with nursery stock.*

Fig. 1.—*Apple tree inoculated with cultures of* Sphæropsis *from cankered apple-tree limbs, showing what was designated " a very good " growth of the fungus.*

Fig. 2.— *Pear tree inoculated with cultures of* Sphæropsis *from cankered apple tree limbs, showing very good growth of the fungus.*

Fig. 3.—*Japanese plum tree inoculated with cultures of* Sphæropsis *from decorticated wood of hop hornbean. Very good growth of the fungus.*

Fig. 4.—*Apple tree inoculated with cultures of* Sphæropsis *from pear twigs, showing slight growth of the fungus.*

Fig. 5.—*Check apple tree; punctured but not inoculated.*

PLATE XXXII.— Fig. 1.—*Young apple tree, top branch killed by inoculating with cultures of* Sphæropsis *from sumach.*

Fig. 2.—*Twig blight of pear and apple respectively caused by inoculating with cultures of* Sphæropsis *from cankered apple tree limbs.*

Fig. 3.—*Quince inoculated with cultures of* Sphæropsis *from cankered apple tree limbs.*

PLATE XXXIII.— Fig. 1.—*Apple tree limb showing Pacific coast apple tree canker.*

Fig. 2.—*Quince tree limb showing canker caused by attack of* Nectria cinnabarina. *(Tode.) Fr.*

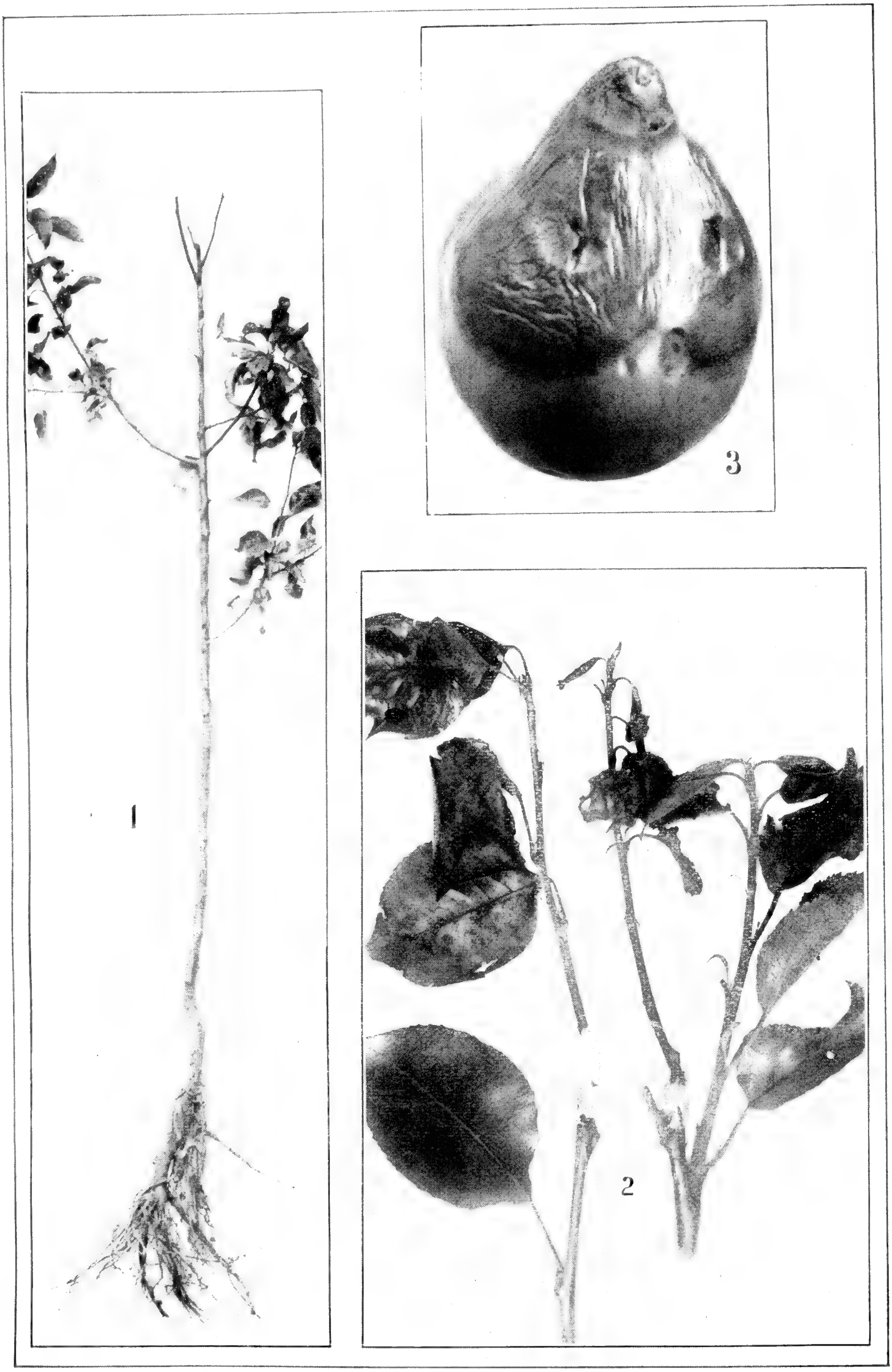

PLATE XXXII.

Plate XXXIII.

FERTILIZING SELF-STERILE GRAPES.*

S. A. Beach.

SUMMARY.

In Bulletin 157 were recorded the results of several seasons' work in testing the self-fertility of the grape. Lists were given of grapes which were perfectly self-fertile, partially self-fertile or self-sterile and completely self-sterile. Many of our cultivated American grapes belong in the last two classes and require cross pollination for formation of perfect bunches. The work of 1899 has been devoted to a study of the question whether some grapes are better than others for fertilizing the self-sterile kinds.

Prevention of accidental cross-pollination was secured by enclosing in paper bags the selected bud clusters of both the variety to be pollinated and that furnishing the pollen. Cross-pollination was effected by removing the pollinating cluster, when in blossom, from the parent vine and enclosing it with the cluster to be fertilized. The clusters were sometimes brushed together before enclosing, sometimes simply enclosed in the paper sacks and shaken, to distribute the pollen.

Twelve nearly or quite self-sterile varieties were treated with pollen from one or more of twenty-four varieties ranging from perfectly self-fertile to self-sterile. The results are given in the body of the bulletin, both in detail and summarized. The use of self-sterile varieties as pollinizers for other self-sterile varieties resulted in failure. Self-sterile varieties fertilized with varieties not strongly self-fertile produced clusters varying in compactness about as did the bunches of the pollinating variety. Self-fertile sorts, with rare exceptions, gave good results when used as fertil-

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* Reprint of Bulletin No. 169.

izers for either partially self-sterile or completely self-sterile varieties. From study of the effect of pollen from different varieties upon the same self-sterile variety, it seems probable that failure to set fruit may be due to several causes, such as dropping off of blossom buds before they open or poor condition of the vine; but the most common cause is imperfect pollination due to impotent pollen.

Lists are given of varieties, both strongly self-fertile and imperfectly self-fertile or self-sterile, which blossom very early, medium early, in mid-season, medium late, late and very late.

INTRODUCTION.

In Bulletin 157 the writer presented a complete account, to that date, of the investigations on the self-fertility of the grape with which he had been engaged for several years.[1] It was therein shown that many of the cultivated varieties of American grapes are either self-sterile or very imperfectly self-fertile. Such kinds, when they are self-pollinated only, either bear no fruit or produce more or less imperfectly filled clusters. In discussing the practical bearing of these discoveries upon the selection of varieties and arranging them in vineyards so as to get the best results in fruit production, attention was called to the fact that self-sterile varieties may produce well filled clusters of fruit when the vines are located near enough to other kinds to make cross-fertilization possible. For this reason the general recommendation was made that whenever the self-sterile or the imperfectly self-fertile kinds are planted it would be well to put near them some other kind which blooms at the same time.

After Bulletin 157 was issued there came from several sources requests for more definite information concerning the mingling of varieties so as to provide for the proper fertilization of those kinds which cannot produce well filled fruit clusters unless they are

[1] Beach, S. A. Self-fertility of the Grape. N. Y. Agr. Exp. Sta. Bul. 157. Dec., 1898.

cross-fertilized. This brought up the question whether some grapes are better than others for fertilizing the self-sterile kinds or whether any variety other than the one to be fertilized will answer the purpose if it blooms at the same time. Similar questions, in one form or another, are apt to arise wherever American grapes are cultivated.

Scarcely any definite information on this subject could be found. Being a subject of considerable practical importance to viticulturists, arrangements were made to begin the investigation of it in 1899. The results of the first season's work in this line are set forth in the following preliminary report of the investigation.

WORK FOR 1899.

PLAN.

Twelve varieties which were selected because they are nearly or quite self-sterile, were artificially cross-pollinated in the manner hereafter described. Twenty-four kinds of grapes were tried as fertilizers for these varieties. Most of them were self-sterile or nearly so, others fully self-fertile, and still others intermediate between these two extremes. The twelve varieties which were artificially cross-pollinated were not emasculated. For the purpose of preventing accidental cross-pollination by means of insects or otherwise, the clusters to be tested were enclosed in paper bags before the blossoms opened, and were kept thus covered during the entire blooming season except the few minutes when the bags were opened to introduce the clusters which furnished the pollen for the test. The clusters which were selected to furnish the pollen were likewise covered before they came into blossom and were kept covered, even after they were removed from the vine which bore them, until they were applied to the self-sterile variety upon which their pollen was to be tried. The bagging of the clusters was done after the manner illustrated and described in Bulletin 157. By thus protecting all of the blossoms which were used in

the tests, the chances of accidental cross-pollination were reduced to a minimum.

After the blossoming season had passed, a record was made to show which clusters had set fruit and which had failed to set fruit. When the fruit was ripe each cluster under test was rated on the scale of 100, according to the percentage of a full cluster which was found. A perfectly formed cluster was rated 100, a half-filled cluster was rated 50 and others were rated in a corresponding manner.

LOCATION OF THE VINEYARDS.

The tests were conducted in 1899 in three quite widely separated localities: In the Station vineyards at Geneva; in the vineyards of E. Smith & Sons at Highlands, on the east bank of Seneca lake, near Lodi; in the vineyard of Mr. E. C. Gillett, Penn Yan, N. Y. Our acknowledgments are due the gentlemen who have consented to allow the experiments to be conducted in their vineyards, and also to Mr. Horace W. Gillett who assisted in the work at Penn Yan in a very careful and satisfactory manner.

The Highlands vineyards are on soil which is derived largely from broken shale. The other vineyards mentioned above are on clay loam.

CROSS-POLLINATION.

The cross-pollinating was done at Highlands, June 12. At Penn Yan it was done June 12, with the exception that Brighton and Salem were crossed each upon the other June 13. At the Station the work of cross-pollinating was done at convenient times during the blooming period from June 10 to 15.

The cross-pollinating which was done at Highlands was under the direction of C. P. Close. The plan there followed was to uncover the cluster which was to receive the pollen. The cluster selected to supply the pollen was then taken from the bag in which it had till this time been kept, and fastened to the first mentioned cluster. Both clusters were then covered with the bag

which had held the cluster which furnished the pollen. After the bag had been closed and labeled, it was shaken so as to agitate the loose pollen which it might contain and possibly assist in more thoroughly distributing it among the open flowers of the cluster which was to be pollinated.

In the Penn Yan tests and in those at the Station, in addition to the treatment above outlined, the open flowers of the cluster which were selected to supply the pollen were brushed over the open flowers which were to be cross-pollinated before fastening the two clusters together. With most varieties the interlocking of the branches of the two clusters was sufficient to hold the loose cluster in place, but in some instances it was necessary to tie the two together. Judging from their appearance when the bags were opened after the blooming season had passed, the flowers of the detached clusters which were not open when the bag was finally closed and labeled, generally failed to open later. It appears, therefore, that the pollen which effected the fertilization of the flowers as shown by the later development of fruit, must have come almost entirely from blossoms which were open when the hand pollinating was done. With some of the varieties which were artificially cross-pollinated after the manner above described, a considerable portion of the flowers were not opened when the hand pollination was done, and probably did not open for a period of from 24 to 48 hours thereafter. Had the bags been reopened on each of the two days following the one upon which the hand pollinating was done, and the clusters brushed again with freshly opened blossoms, the result might have given a more accurate indication of the kind of clusters which such varieties may be expected to produce when they stand adjacent to each other, and the process of cross-pollination goes on freely during the entire blooming season.

On the other hand it should be observed in this connection that, even with varieties which had not come into full bloom when the hand pollinating was done, some perfectly filled clusters were obtained, showing that the percentage of blossoms which became

cross-pollinated was, under the circumstances, remarkably large. Take, for example, the results with Brighton fertilized by Catawba. Both at Highlands and Penn Yan these varieties had a large percentage of unopened blossoms when the Catawba clusters were applied to the Brighton. Eight Brighton clusters at Highland were thus supplied with Catawba pollen and all of them set fruit. When the fruit was ripe one cluster ranked 95, one 90, one 85. The two lowest were rated 55 and the average rating was 74.4. At Penn Yan five Brighton clusters were likewise supplied with Catawba pollen. One cluster so treated ripened but four fruits, one was almost perfectly filled and the remaining three were well filled. Omitting the first named cluster, the average rating was 97.5; including it the average was 80. While, as has been said before, these averages cannot be taken as indicating with strict accuracy the efficiency of Catawba as a fertilizer for the Brighton, they show that, even under the most unfavorable conditions which obtained in these trials, a surprisingly large proportion of the blossoms became cross-pollinated. In all cases where the number of clusters under experiment is large enough to give some indication of the value of the variety as a fertilizer for self-sterile sorts the results with the different varieties may be looked upon as comparable, because the treatment was similar in all the tests with the exception that in the Highlands vineyard the clusters to be cross-pollinated were not brushed with the cluster selected for furnishing the pollen, but the two kinds of clusters were simply inclosed in the bag and shaken together.

COVERING THE CLUSTERS.

As has already been stated, all of the clusters which were used in these experiments were covered before the blossoms opened, using paper bags for this purpose after the manner described in Bulletin 157. This work was largely done before the varieties commenced to bloom. The clusters in the Highlands tests were bagged June 7 and 8; with few exceptions those at Penn Yan were bagged June 9; and those at the Station were bagged at various

times from June 5 to June 10. In a few cases the variety had begun to bloom before this work was done. Great care was then taken that no cluster with an open blossom should be bagged.

THE BLOOMING PERIOD.

At Highlands the following observations on the blooming varieties were made in forenoon of May 8:

Aminia — Beginning to bloom.

Brighton — None in bloom; probably will not begin to bloom before June 12.

Catawba — Ditto.

Niagara — Not many blossoms open.

Worden — Nearly half in bloom.

Wyoming — First blossoms opening.

On Monday, June 12, when the cross-pollinating was done, Aminia was in some cases nearly out of bloom. Brighton was hardly enough advanced in bloom to furnish an abundant supply of pollen. With these exceptions no difficulty in finding clusters in good condition for the cross-pollinating was noted.

At Penn Yan the following notes on the condition of bloom were made when the cross-pollinating was done June 12:

Brighton — Many clusters have no open blossoms, but the majority of clusters have at least begun to bloom.

Catawba — About the same stage of advancement as Brighton.

Eldorado — Nearly in full bloom.

Herbert — Past full bloom and going out of bloom.

Lindley — Most clusters are coming into bloom; a few have not yet begun to bloom.

Merrimack — Nearly in full bloom.

Salem — Past full bloom and going out of bloom.

Niagara — Nearly in full bloom.

Worden — Nearly in full bloom.

The period of bloom in 1899 of the varieties which were under test at the Station is shown in the following table. The first date shows the opening of the first blossoms, the second date shows when the variety reached full bloom and the last date shows when the last blossoms were seen.

TABLE I.— PERIOD OF BLOOM IN 1899 OF EXPERIMENTAL VARIETIES IN THE STATION VINEYARD.

Location		Name.	Period of bloom.		
Vineyard.	Row.		First bloom.	Full bloom	Last bloom.
8..	13	Aminia	June 9	June 12	June 15
8..	22	Barry	June 8	June 12	June 15
8..	6	Black Eagle	June 13	June 15	June 20
8..	24	Black Eagle	June ?	June 14	June 20
11..	20	Black Eagle	June 10	June 13	June 16
8..	7	Brighton	June 12	June 14	June 18
11..	19	Brighton	June 9	June 11	June 15
11..	23	Catawba	June 7	June 9	June 15
11..	26	Catawba	June 8	June 11	June 15
8..	4	Columbian Imperial	June 7	June 10	June 13
11..	17	Columbian Imperial	June 7	June 9	June 11
8..	7	Creveling	June 10	June 13	June 15
11..	16	Eaton	June 9	June 11	June 13
11..	25	Eaton	June 7	June 9	June 13
8..	8	Eldorado	June 13	June 15	June 19
11..	26	Eumelan	June 8	June 10	June ?
8..	13	Herbert	June 9	June 12	June 14
8..	15	Hercules	June 9	June 11	June 15
11..	25	Jefferson	June 13	June 15	June 17
7..	3	Jefferson	June 12	June 15	June ?
11..	25	Lindley	June 9	June 10	June 15
8..	10	Merrimack	June 10	June 13	June 15
8..	11	Nectar	June 10	June 14	June 20
11..	20	Nectar	June 10	June 14	June 16
11..	24	Niagara	June 7	June 9	June 13
11..	26	Rochester	June 7	June 9	June 15
11..	26	Salem	June 9	June 10	June ?
11..	7	Station 125	June 10	June 12	June 21
11..	8	Station 146	June 9	June 12	June 21
11..	9	Station 156	June 10	June 12	June 20
11..	25	Vergennes	June 7	June 10	June 14
8..	1	Worden	June 9	June 12	June 16
11..	24	Worden	June 7	June 9	June 14
8..	17	Wyoming	June 10	June 13	June 15

DETAILED STATEMENT OF THE RESULTS.

Notes on the results were made at two different periods. First, soon after the vines had gone out of bloom a record was made of

the clusters which failed to set fruit. It is best to make such records early in the season because late in the season it may be impossible to decide whether the absence of a cluster means that it failed to set fruit or that the cluster was accidentally broken off. After the fruit ripened each cluster was rated on the scale of 100 according to the percentage of a full cluster of fruit which was found, as has already been stated under "Plan of Work." The detailed records are here given for each variety together with the records which the same variety has made in previous years when tested as to its self-fertility. Unless otherwise stated the tests here reported were made in 1899.

The results are summarized and presented graphically on the pages following the discussion of the separate varieties.

AMINIA.

Aminia self-pollinated.— In 1892, 2 clusters of Aminia which were kept covered during blooming season gave no fruit; in 1898, 9 clusters which were likewise tested gave no fruit. In 1899, 6 clusters of Aminia at Highlands were hand-pollinated[2] with Aminia pollen brought from the Station, but no fruit set; 10 clusters which were kept covered during the blooming season were rated 0, 0, 0, 0, 0, 0, 0, 0, 0, 12 respectively. Average rating 1.2. So far as tested Aminia is practically self-sterile.

Aminia pollinated with Brighton.—Six clusters tested at Highlands were rated respectively 0, 0, 0, 0, 0, 10. Average rating 1.7.

Aminia pollinated with Wyoming.— Five clusters tested at Highlands were rated respectively 0, 0, 0, 0, 20. Average rating 4.

Aminia pollinated with Niagara.— One cluster tested at Highlands rated 80.

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2 By "hand pollinating," is here meant brushing the clusters with the open flowers from another vine of the same kind, and then inclosing the pollinated cluster together with the cluster which furnished the pollen in a bag according to the method followed in the 1899 experiments in cross-pollinating, as described on a preceding page.

Aminia pollinated with Worden.— Two clusters tested at Highlands were rated respectively 88, 88. Average rating 88.

Aminia pollinated with Catawba.— Four clusters tested at Highlands were rated respectively 88, 88, 90, 90. Average rating 89.

Aminia as a fertilizer.— The records of the tests of Aminia pollen upon Brighton and Wyoming are given under the discussion of these varieties. (See Index for pages.)

BARRY.

Barry self-pollinated.— In 1892, 2 clusters of Barry which were kept covered during the blooming season gave no fruit. Ten clusters in 1895 and 8 clusters in 1898 which were likewise covered gave no fruit. So far as tested Barry has proved completely self-sterile.

Barry pollinated with Black Eagle.— Five clusters tested at the Station gave no fruit.

Barry pollinated with Hercules.— Five clusters tested at the Station gave no fruit.

The vine on which these tests with the pollen of Black Eagle and Hercules were made stands in a mixed vineyard. The uncovered clusters were well formed and the yield abundant.

BLACK EAGLE.

Black Eagle self-pollinated.— In 1892, 2 clusters of Black Eagle which were kept covered during the blooming season gave no fruit; 10 clusters likewise covered in 1895 gave no fruit. So far as tested Black Eagle is completely self-sterile. Standing in a mixed vineyard it has produced some well-formed clusters, but often the clusters are imperfectly filled.

Black Eagle pollinated with Brighton.— Four clusters tested at the Station gave no fruit.

Black Eagle pollinated with Worden.— One cluster tested gave no fruit.

Black Eagle as a fertilizer.— The records of the test of Black Eagle pollen upon Barry are given under the latter variety.

BRIGHTON.

Brighton self-pollinated.— In 1892, 9 clusters of Brighton which were kept covered during the blooming season gave no fruit; 5 clusters at the Station in 1895, 27 clusters at the Station in 1897 and 9 clusters at Penn Yan in 1899 likewise covered gave no fruit. In another vineyard, of 25 clusters covered in 1897 24 clusters were rated 0, 1 cluster rated 10. Average rating 0.4. In still another locality 5 clusters likewise tested in 1897 were rated respectively 0, 0, 10, 10, 10. Average rating 6. At Highlands in 1899, of 28 clusters which were tested, 26 clusters were rated 0, 1 cluster rated 1 and 2 clusters rated 4. Average rating 0.2. At Penn Yan 5 clusters were hand-pollinated[3] with Brighton pollen from another vine. Four of these rated 0 and 1 rated 4. Average rating 0.8. At Highlands 10 clusters were likewise pollinated with Brighton pollen from a Station vineyard. Six of these were rated 0, 3 rated 2 and 1 rated 15. Average rating 2.1. From these tests it appears that Brighton clusters when self-pollinated rarely set any fruit and the variety may be called practically self-sterile.

Brighton pollinated with Creveling.— Seven clusters tested at Highlands gave no fruit.

Brighton pollinated with Salem.— Four clusters tested at Penn Yan gave no fruit.

Brighton pollinated with Aminia.— Six of the seven clusters tested at Highlands were rated 0 and 1 rated 2. Average rating 0.3.

Brighton pollinated with Wyoming.— Six clusters were tested at Highlands; 5 clusters gave a rating of 0 and 1 gave a rating 2. Average rating 0.3.

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[3] See foot note 2, page 340.

Brighton pollinated with Lindley.— Four of the five clusters tested at Penn Yan were rated 0 and 1 rated 10. Average rating 2.

Brighton pollinated with Eldorado.— Four clusters tested at Penn Yan were rated respectively 0, 0, 6, 15. Average rating 5.2.

Brighton pollinated with Station 146[4] — Four clusters tested at Penn Yan were rated respectively 0, 0, 25, 60. Average rating 21.3.

Brighton pollinated with Station 156[4].— Four clusters tested at Penn Yan were rated respectively 4, 85, 88, 100. Average rating 69.3.

Brighton pollinated with Merrimack.— Four clusters tested at Penn Yan were rated respectively 0, 0, 0, 100. Average rating 25.

Since Merrimack is self-sterile, and because in the other tests it uniformly failed to fertilize self-sterile sorts, and because in these tests on Brighton it failed to fertilize three of the four clusters upon which it was tried, while the fourth cluster was rated 100, it is desirable that these tests be repeated before definite conclusions are drawn. Similar results, however, were obtained by pollinating Brighton with Herbert, and Herbert like Merrimack is self-sterile.

Brighton pollinated with Herbert.— Four clusters tested at Penn Yan were rated respectively 0, 12, 25, 75. Average rating 28. Compare this record with results given in the preceding paragraph.

Brighton pollinated with Nectar.— Five clusters tested at Penn Yan were rated respectively 0, 20, 50, 50, 75. Average rating 40.

Brighton pollinated with Vergennes.— Seven clusters tested at Highlands were rated respectively 2, 40, 60, 75, 100, 100. Average rating 53.9. One of the perfect clusters was an unusually

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[4] Station 146 and Station 156 are male hybrids of *Vitis labrusca* L., by *Vitis bicolor*, Le Co te. They were produced by crossing a wild male *bicolor* upon the Winchell.

large, double, perfectly filled cluster. The other perfect cluster was also a very fine one.

Brighton pollinated with Jefferson.— Five clusters tested at Penn Yan were rated respectively 0, 25, 40, 60, 95, 100. Average rating 64.

Brighton pollinated with Rochester.— Five clusters tested at Penn Yan were rated respectively 0, 85, 85, 90, 100. Average rating 72.

Brighton pollinated with Catawba.— Eight clusters tested at Highlands were rated respectively 55, 55, 60, 75, 80, 85, 90, 95. Average rating 74.4.

At Penn Yan five clusters of Brighton pollinated with Catawba were rated 10, 90, 100, 100, 100, respectively. Average rating 80. As stated on a previous page, many of the blossoms of these two varieties had not yet opened when the hand pollinating was done.

Brighton pollinated with Worden.— Eight clusters tested at Highlands were rated respectively 50, 75, 78, 80, 80, 83, 85, 85. Average rating 77. Four clusters tested at Penn Yan were rated respectively 4, 100, 100, 100. Average rating 76.

Brighton pollinated with Niagara.— Nine clusters tested at Highlands were rated respectively 75, 80, 88, 88, 88, 88, 88, 88, 88. Average rating 85.7.

Five clusters tested at Penn Yan were rated respectively 2, 10, 60, 88, 100. Average rating 52.5.

Brighton pollinated with Station 125[5]. Five clusters tested at Penn Yan were rated respectively 50, 100, 100, 100, 100. Average rating 90.

Brighton as a fertilizer.— Tests of Brighton as a fertilizer for self-sterile varieties were made with several self-sterile kinds of grapes. The results are given in detail under Aminia, Black Eagle, Eldorado, Herbert, Hercules, Lindley, Merrimack, Salem and Wyoming. (See Index for pages.)

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5 Station 125 is a white seedling of Winchell fertilized by Diamond. It is perfectly self-fertile.

CATAWBA.

Catawba self-pollinated.— In 1894, 12 clusters of Catawba which were kept covered during the blooming season, were, with one exception, nearly perfectly filled, averaging about 90. At Penn Yan 16 clusters which were likewise tested in 1897 were rated 50, 70, 70, 70, 70, 80, 80, 90, 90, 90, 90, 90, 90, 90, 90, 100, respectively. Average rating 81.9. At Branchport in 1897, of 22 clusters which were likewise tested, 1 was rated 70, 9 rated 80 and 12 rated 90, respectively, averaging 85. In 1899, of 42 clusters likewise tested at Highlands, 4 rated 80, 1 rated 83, 3 rated 85, 11 rated 88, 11 rated 90, 2 rated 93, 4 rated 95, 1 rated 97, 2 rated 98 and 3 rated 100, respectively, averaging 89.9. Twenty-four clusters were tested at Penn Yan, of which 5 were rated 0, 75, 75, 78 and 80, respectively, 5 rated 88, 6 rated 90, 7 rated 95 and 1 rated 98, averaging 85.5. Seventeen clusters which were tested at the Station were rated 50, 75, 80, 83, 85, 88, 88, 90, 90, 90, 90, 90, 90, 90, 95, 95, 95, respectively, averaging 86.1.

Taking all these tests into consideration it appears that Catawba is strongly self-fertile and when self-pollinated generally forms well-filled clusters of fruit.

Catawba as a fertilizer.— Several tests were made with Catawba as a fertilizer for self-sterile varieties. The results are given in detail under Aminia, Brighton, Eldorado, Herbert, Lindley, Merrimack, Salem and Wyoming.

COLUMBIAN IMPERIAL.

Columbian Imperial self-pollinated.— In 1897, 8 clusters of Columbian Imperial which were kept covered during the blooming season, were rated 90, 90, 90, 100, 100, 100, 100, 100, respectively, averaging 96.3. It appears to be fully self-fertile.

Columbian Imperial as a fertilizer.— It was used as a fertilizer for Hercules. See page 378.

CREVELING.

Creveling self-pollinated.— In 1894, 5 clusters of Creveling were kept covered during the blooming season, none of which

gave any fruit. In 1895, 5 clusters, aud 1897, 5 clusters, which were likewise tested, gave no fruit. From these tests it appears that Creveling is absolutely self-sterile.

Creveling as a fertilizer.— It was tried as a fertilizer for Brighton, but no fruit was produced. See page 372.

It is interesting to note in this connection that, although Creveling failed to fertilize Brighton, the parentage of Mills is given as a Muscat Hamburg fertilized with Creveling.

EATON.

Eaton self-pollinated.— In 1894, 10 clusters which were kept covered during the blooming season gave no fruit. From the fact that the vine which was used for this test proved to be neither in a vigorous nor in a productive condition these results were not looked upon as conclusive. In 1899, 6 clusters on another vine, which were likewise covered, were rated 75, 80, 90, 95, 100, 100, respectively, averaging 90.

Eaton as a fertilizer.— It was tried as a fertilizer for Hercules. See page 378.

ELDORADO.

Eldorado self-pollinated.— In 1894, 5 clusters of Eldorado which were kept covered during the blooming season, gave no fruit. In 1895, 10 clusters; in 1897, 23 clusters; and in 1899, 4 clusters likewise tested gave no fruit.

The following tests of Eldorado were made at Penn Yan in 1899:

Eldorado pollinated with Brighton.— Five clusters tested gave no fruit.

Eldorado pollinated with Herbert.— Five clusters tested gave no fruit.

Eldorado pollinated with Lindley.— Five clusters tested gave no fruit.

Eldorado pollinated with Salem.— Five clusters which were tested were rated respectively 0, 0, 0, 0, 2. Average rating 0.4.

Eldorado pollinated with Catawba.— Four clusters which were tested were rated, respectively, 0, 0, 0, 2. Average rating 0.5.

Catawba is a self-fertile variety. In these tests self-fertile sorts have generally been good fertilizers for the self-sterile kinds. No explanation is offered for the exceptional results which followed the pollination of Eldorado with Catawba. There seems to be no good ground for the opinion that the Eldorado pistils were defective, for the clusters on the tested vines which were open to cross-pollination were unusually well formed, and some excellent clusters were also obtained by fertilizing Eldorado with Worden and Niagara. Catawba fertilized other self-sterile sorts very successfully in these tests, with the exception of Salem.[6]

Eldorado pollinated with Worden.— Five clusters which were tested were rated respectively 20, 60, 75, 75, 95. Average rating 65.

Eldorado pollinated with Niagara.— Five clusters which were tested were rated respectively 50, 60, 75, 95, 100. Average rating 76.

Eldorado as a fertilizer.— Eldorado was tried as a fertilizer on two self-sterile sorts, Brighton and Herbert, under which varieties will be found the details of the tests.

EUMELAN.

Eumelan self-pollinated.— In 1892, 10 clusters of Eumelan which were kept covered during the blooming season, gave no fruit. In 1895, 9 clusters which were likewise tested gave no fruit. In 1893, 3 clusters which were likewise tested were rated respectively 0, 0, 4. Average rating 1.3. In 1899, 1 cluster which was likewise tested was rated 20. In view of all these tests it appears that with rare exceptions Eumelan fails to set any fruit when self-pollinated, and it may be classed as practically self-sterile.

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6 Salem fertilized by Catawba, rated 4, but only a single cluster was tested so that no conclusions can be drawn till the results are verified by further investigation.

Eumelan pollinated with Black Eagle.— Two clusters tested at the Station gave no fruit. The work was done on the fifth day after Eumelan came into full bloom, and the treated clusters may have been too far advanced in bloom to give favorable results from cross-pollination. These tests should be repeated.

HERBERT.

Herbert self-pollinated.— In 1892, 2 clusters of Herbert which were kept covered during the blooming season gave no fruit.

In 1895, 5 clusters and in 1899, 9 clusters, which were likewise tested, gave no fruit. So far as tested, Herbert has been found self-sterile.

The following tests with Herbert in 1899 were made at Penn Yan:

Herbert pollinated with Brighton.— One cluster which was tested gave no fruit.

Herbert pollinated with Eldorado.— Four clusters which were tested gave no fruit.

Herbert pollinated with Lindley.— Five clusters which were tested gave no fruit.

Herbert pollinated with Merrimack.— Five clusters which were tested gave no fruit.

Herbert pollinated with Salem.— Four clusters which were tested gave no fruit.

Herbert pollinated with Worden.— Five clusters which were tested were rated respectively 95, 95, 95, 100, 100. Average rating 97.

Herbert pollinated with Niagara.— Four clusters which were tested were rated respectively 95, 100, 100, 100. Average rating 98.8.

Herbert pollinated with Catawba.— Two clusters which were tested were rated respectively 100, 100. Average rating 100.

Herbert as a fertilizer.— Herbert was tried as a fertilizer on three self-sterile sorts, Brighton, Eldorado and Salem. See pages 372, 375, 381, respectively.

HERCULES.

Hercules self-pollinated.— In 1893, 4 clusters of Hercules which were kept covered during the blooming season, bore no fruit. In 1895, 10 clusters tested in like manner gave no fruit. In 1899, 1 cluster covered in like manner produced a well-formed cluster made up entirely of small, seedless fruits.

Hercules pollinated with Brighton.— Two clusters were tested in a Station vineyard, one of which set no fruit, the other was filled with seedless fruits like the cluster described in the last paragraph.

Hercules pollinated with Columbian Imperial.— Five clusters in a Station vineyard were tested. They were rated 20, 30, 30, 40, 50, respectively, averaging 36.

Hercules pollinated with Eaton.— Five clusters in a Station vineyard were tested. They were rated 0, 0, 30, 70, 70, respectively, averaging 36.

Hercules as a fertilizer.— Hercules was tried as a fertilizer for Barry. See page 370.

JEFFERSON.

Jefferson self-pollinated.— In 1893, 3 clusters of Jefferson were kept covered during the blooming season. They rated on the average about 95. In 1894, 4 clusters likewise tested were rated 0, 100, 100, 100, respectively, averaging 75. In 1899, 7 clusters were covered on a vine which afterwards appeared to be not in a satisfactory condition for testing. These clusters were rated 20, 20, 25, 45, 45, 60, 60, respectively, averaging 39.3. From these tests it appears that Jefferson is strongly self-fertile when the vine is in good condition.

Jefferson as a fertilizer.— Pollen from the vine which in 1899 made the record which is given in the preceding paragraph, was tried on Brighton. See page 373.

LINDLEY.

Lindley self-pollinated.— In 1894, 10 clusters of Lindley, which were kept covered during the blooming season, set no fruit. In

1895, 9 clusters and in 1897, 25 clusters, which were likewise covered, set no fruit. In another locality, of 25 clusters which were likewise tested in 1897, 24 were rated 0, and 1 rated 40. Average rating 1.6. In view of these tests, Lindley may be called practically self-sterile.

The following tests with Lindley in 1899 were made at Penn Yan:

Lindley pollinated with Merrimack.— Three clusters which were tested produced no fruit.

Lindley pollinated with Salem.— Five clusters which were tested gave no fruit.

Lindley pollinated with Brighton.— Three clusters which were tested were rated 0, 0, 12, respectively, average rating 4.

Lindley pollinated with Catawba.— Five clusters which were tested were rated 40, 40, 55, 85, 95, respectively. Average rating 63.

Lindley pollinated with Worden.— Five clusters which were tested were rated 0, 50, 100, 100, 100, respectively. Average rating 70.

Lindley pollinated with Niagara.— Five clusters which were tested were rated 40, 70, 90, 90, 95, respectively, averaging 77.

Lindley as a fertilizer.— Several tests were made with Lindley as a fertilizer for self-sterile sorts. The results are given in detail for Brighton, Eldorado, Herbert, Merrimack and Salem under the several discussions of these varieties.

MERRIMACK.

Merrimack self-pollinated.— In 1892, 2 clusters which were tested, gave no fruit. In 1895, 10 clusters; in 1897, 23 clusters, and in 1899, 3 clusters, which were likewise tested, gave no fruit. From these tests it appears that Merrimack is completely self-sterile.

The following tests with Merrimack were made at Penn Yan:

Merrimack pollinated with Salem.— Five clusters which were tested, were rated 0, 0, 0, 0, 4, respectively. Average rating 0.8.

Merrimack pollinated with Brighton.— Four clusters which were tested, were rated 0, 0, 0, 35, respectively. Average rating 8.8.

Merrimack pollinated with Lindley.— Four clusters which were tested, were rated 0, 15, 15, 98, respectively. Average rating 32.

Merrimack pollinated with Catawba.— Three clusters which were tested, were rated 90, 90, 95, respectively. Average rating 91.7.

Merrimack pollinated with Niagara.— Four clusters which were tested, were rated 95, 95, 95, 100, respectively. Average rating 96.3.

Merrimack pollinated with Worden.— Four clusters which were tested, were rated 90, 98, 100, 100, respectively. Average rating 97.

Merrimack as a fertilizer.— Several tests were made with Merrimack as a fertilizer for self-sterile sorts. The results are given in detail under the discussions of Brighton, Herbert, Lindley and Salem.

NECTAR.

Nectar self-pollinated.— In 1894, 6 of the 9 clusters which were kept covered during the blooming season were rated 0, 2 rated 2 and 1 rated 4, averaging 0.9 per cluster. In 1899, 2 clusters which were likewise tested, rated 80, 100, averaging 90. Further testing is needed to determine whether or not Nectar is strongly self-fertile.

Nectar as a fertilizer.— It was tried as a fertilizer for Brighton. See page 372.

NIAGARA.

Niagara self-pollinated.— In 1892, 10 clusters of Niagara, which were kept covered during the blooming season, gave perfect clusters, which rated from 97 to 100. In 1897, of 23 clusters at Penn Yan, which were likewise tested, 1 was rated 40, 5 rated 60, 3 rated 70, 9 rated 80, 3 rated 90, and 2 rated 100, respectively, averaging 75.7. Twelve clusters tested at Branchport were

rated 30, 40, 50, 60, 60, 60, 70, 80, 80, 80, 80, 100, averaging 65.8.

In 1899, 16 Niagara clusters at Highlands were likewise tested. They were rated 85, 90, 90, 90, 93, 93, 93, 95, 95, 98, 100, 100, 100, 100, 100, 100, respectively, averaging 95.1. At Penn Yan, 20 clusters which were likewise tested, were rated 65, 80, 88, 90, 90, 90, 95, 95, 95, 95, 95, 98, 98, 98, 98, 98, 98, 100, 100, 100, respectively, averaging 93.3.

Taking all these tests into consideration it appears that generally Niagara is strongly self-fertile.

Niagara as a fertilizer.— Several tests were made with Niagara as a fertilizer for self-sterile sorts. The results in detail are given under Aminia, Brighton, Eldorado, Herbert, Lindley, Merrimack and Salem.

ROCHESTER.

Rochester self-pollinated.— In 1894, 10 clusters of Rochester, which were kept covered during the blooming season, all gave very compact and perfect clusters of fruit. One cluster, which was likewise tested in 1899, gave a perfect cluster of fruit, rated at 100. From these tests it appears that Rochester is perfectly self-fertile.

Rochester as a fertilizer.— It was tried as a fertilizer for Brighton. See page 373.

SALEM.

Salem self-pollinated.—In 1892, 10 clusters of Salem, which were kept covered during the blooming season, set no fruit. In 1897, 23 clusters in one locality, and 5 clusters in another, which were likewise tested, gave no fruit. From these tests it appears that Salem is completely self-sterile.

The following tests with Salem were made in 1899 at Penn Yan:

Salem pollinated with Brighton.— Three clusters which were tested produced no fruit.

Salem pollinated with Herbert.— Five clusters which were tested gave no fruit.

Salem pollinated with Merrimack.— Four clusters which were tested gave no fruit.

Salem pollinated with Lindley.— Four clusters which were tested were rated 0, 0, 0, 0, 2, respectively. Average rating 0.4.

Salem pollinated with Catawba.— One cluster which was tested was rated 4. The test should be repeated and a large number of clusters tried before drawing conclusions on the value of Catawba as a fertilizer for Salem. Catawba gave similar results when used with Eldorado. See page 376.

Salem pollinated with Worden.— Five clusters which were tested were rated 60, 90, 95, 100, 100. Average rating 89.

Salem pollinated with Niagara.— Five clusters which were tested were rated 95, 95, 100, 100, 100. Average rating 98.

Salem as a fertilizer.— Several tests were made with Salem as a fertilizer for self-sterile sorts. The results are given in detail under Brighton, Eldorado, Herbert, Lindley and Merrimack.

STATION 125.

Station 125 *self-pollinated.*— In 1899, 10 clusters of *Station* 125 were kept covered during the blooming season. They all gave perfect clusters, the average rating being 100. *Station* 125 is a white seedling of Winchell, fertilized with Diamond.

Station 125 *as a fertilizer.*— It was tried as a fertilizer for Brighton. See page 373.

STATION 146.

Station 146 is a male vine, a seedling of Winchell fertilized by a wild vine of *Vitis bicolor* Le Conte. It is, therefore, a hybrid of *V. labrusca by V. bicolor*. It was tried as a fertilizer for Brighton. See page 372.

STATION 156.

Station 156 is also a male vine having the same parentage as *Station* 146 which is given in the preceding paragraph. It was used as a fertilizer for Brighton. See page 372.

VERGENNES.

Vergennes self-pollinated.— In 1894, 10 clusters which were kept covered during the blooming season gave clusters of fruit which on the average were about as well filled and as compact as ordinary Concords. In 1897, 22 clusters which were tested at Penn Yan were rated 0, 0, 20, 30, 30, 30, 40, 40, 40, 40, 50, 50, 50, 50, 50, 60, 60, 60, 60, 60, 70, 90, respectively, averaging 44.5. At Branchport 5 clusters which were likewise tested, were rated 0, 0, 40, 40, 40. They averaged 24.

In 1899, 8 clusters were tested in a Station vineyard. They rated 70, 70, 70, 75, 80, 80, 85, 90, respectively, averaging 77.5. On another vine which has stood in uncultivated ground and has repeatedly been overloaded with fruit, 9 clusters were also tested. These rated 0, 0, 0, 2, 65, 75, 85, 88, 95, respectively, and averaged 45.6.

From these tests it appears that Vergennes is not always strongly self-fertile.

Vergennes as a fertilizer.— It was tried as a fertilizer for Brighton. See page 372.

WORDEN.

Worden self-pollinated.— In 1894, 10 clusters of Worden which were kept covered during the blooming season gave clusters which varied from perfect or nearly so to somewhat loose, averaging somewhat loose. In 1895, 9 clusters which were tested were perfectly filled with fruit. In 1897, 23 clusters in a Station vineyard were tested; 2 clusters were rated 80, 4 rated 90 and 17 rated 100, respectively, averaging 96.5. At Penn Yan, of 20 clusters which were tested, 2 were rated 80, 7 rated 90 and 11 rated 100, respectively, averaging 94.5. At Branchport 5 clusters which were tested were rated 80, 80, 80, 90, 90, respectively, averaging 84.

In 1899, 6 clusters in a Station vineyard which were likewise tested were rated 90, 90, 95, 100, 100, 100, respectively, and averaged 95.8. At Highlands, of 24 clusters which were tested, 3 were rated 75, 83 and 85, respectively, and 3 were rated 88, 3

rated 90, 5 rated 95, 2 rated 98 and 8 rated 100, respectively, averaging 93.7. At Penn Yan 20 clusters were likewise tested. Seven of these were rated 75, 90, 90, 95, 95, 95 and 98, respectively, and 13 were rated 100. The average was 96.9.

From these tests it appears that Worden, generally, is strongly self-fertile.

Worden as a fertilizer.— Several tests were made with Worden as a fertilizer for self-sterile sorts. The results in detail are given under Aminia, Black Eagle, Brighton, Eldorado, Herbert, Lindley, Merrimack and Salem.

WYOMING.

Wyoming self-pollinated.— In 1896, 10 clusters of Wyoming which were kept covered during the blooming season gave no fruit. In 1899, 4 clusters which were likewise tested at the Station were rated 0, 0, 0, 4, respectively. Average rating 1. At Highlands 13 clusters were kept covered during the blooming season. Twelve of them set no fruit. The remaining cluster was well filled. It was on a shoot which had been bent in tying it to the trellis so that the flow of sap was somewhat checked. Before it had been rated it was taken by other parties. It would probably rank as high as 90. On the same vines the uncovered clusters which were exposed during the blooming season to cross-pollination were often well-filled, but sometimes loose and quite imperfectly filled clusters were found.

At Highlands 6 clusters were hand-pollinated[7] with Wyoming pollen taken from a vine in a Station vineyard. They rated 0, 0, 5, 10, 25, 90, respectively. Average rating 21.6.

In view of all of these tests, it appears, that although Wyoming may sometimes produce a small amount of fruit when self-pollinated, for all practical purposes it may be ranked as self-sterile.

The following tests were made in 1899 with Wyoming at Highlands:

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[7] See foot note page 369.

Wyoming pollinated with Aminia.— Four clusters which were tested, were rated 0, 0, 0, 8, respectively. Average rating 2.

Wyoming pollinated with Brighton.— Six clusters which were tested, were rated 0, 0, 0, 0, 22, 50, respectively. Average rating 12.

Wyoming pollinated with Catawba.— One cluster which was tested formed a perfect cluster of fruit. It was rated 100.

Wyoming as a fertilizer.— It was tried as a fertilizer on two self-sterile sorts, Aminia, page 369, and Brighton, page 371.

SUMMARY OF RESULTS.

In the following summary of the results of the investigation the data which have been given on preceding pages are arranged in Table II with reference to the ability of each variety to fertilize the self-sterile sorts upon which it was tried as compared with its ability to fertilize itself, and in Table III with reference to the varying degrees of fruitfulness which the self-sterile varieties exhibit when they are supplied with pollen from various varieties, some of which are more or less self-sterile and others self-fertile.

Explanation of tables.— The x between two names indicates that the variety following the x was used in pollinating the variety whose name appears before the x. Thus, Brighton x Aminia indicates that the Brighton clusters were pollinated with Aminia pollen in the manner described on page 364. The rating is on the scale of 100 points as previously explained, a perfectly formed and perfectly filled cluster ranking 100. The average rating is shown graphically and the number of tested clusters upon which the average is based is also stated. The highest rating which any single cluster in the test received is also given.

" Self-pollinated " indicates that the tested clusters were simply kept covered in paper bags during the blooming season. Sometimes the self-pollination was performed by hand, pollen from another vine of the same kind being applied in the manner described in the foot-note, page 369. Such tests are marked " hand pollinated " in the table.

TABLE II.—COMPARATIVE FRUITAGE WITH DIFFERENT VARIETIES OF GRAPES TRIED AS FERTILIZERS FOR SELF-STERILE SORTS.

VARIETIES TESTED.	Number of clusters under test.	Highest rating.	Average rating.	Graphic representation of average rating.
Aminia as a fertilizer:				
Self-pollinated	2	0.	0.	
Self-pollinated	9	0.	0.	
Self-pollinated	6	0.	0.	
Self-pollinated	10	12.	1.2	
Brighton x Aminia	7	2.	0.3	
Wyoming x Aminia	4	8.	2.	
Black Eagle as a fertilizer:				
Self-pollinated	2	0.	0.	
Self-pollinated	10	0.	0.	
Barry x Black Eagle	5	0.	0.	
Eumelan x Black Eagle	2	0.	0.	
Brighton as a fertilizer:				
Self-pollinated	9	0.	0.	
Self-pollinated	5	0.	0.	
Self-pollinated	27	0.	0.	
Self-pollinated	9	0.	0.	
Self-pollinated	28	4.	0.2	
Self-pollinated	25	10.	0.4	
Self-pollinated*	5	4.	0.8	
Self-pollinated*	10	15.	2.1	
Self-pollinated	5	10.	6.0	
Black Eagle x Brighton	4	0.	0.0	
Eldorado x Brighton	5	0.	0.0	
Herbert x Brighton	1	0.	0.0	
Salem x Brighton	3	0.	0.0	
Aminia x Brighton	6	10.	1.7	
Lindley x Brighton	3	12.	4.0	
Merrimack x Brighton	4	35.	8.8	
Wyoming x Brighton	6	50.	12.0	
Hercules x Brighton†	2	?	?	
Catawba as a fertilizer:				
Self-pollinated	12	‡	‡	
Self-pollinated	16	100.	81.9	
Self-pollinated	22	90.	85.0	
Self-pollinated	37	100.	89.9	
Self-pollinated	24	98.	85.5	
Self-pollinated	17	95.	86.1	
Eldorado x Catawba	4	2.	0.5	
Salem x Catawba	1	4.	4.0	
Lindley x Catawba	5	95.	63.0	

* Hand-pollinated.

† See page 378.

‡ The clusters were perfect, or nearly so, but were not rated on the scale of 100 points.

TABLE II — *Continued.*

VARIETIES TESTED.	Number of clusters under test	Highest rating.	Average rating.	Graphic representation of average rating.
Brighton x Catawba....	8	95.	74.4	
Brighton x Catawba...	5	100.	80.0	
Aminia x Catawba......	4	90.	89.0	
Merrimack x Catawba..	3	95.	91.7	
Herbert x Catawba.....	2	100.	100.	
Wyoming x Catawba...	1	100.	100.	
Columbian Imperial as a fertilizer:				
Self-pollinated..........	8	100.	96.3	
Hercules x Colum. Imp.	5	50.	36.0	
Creveling as a fertilizer:				
Self-pollinated..........	5	0.	0.0	
Self-pollinated....... .	5	0.	0.0	
Self-pollinated	5	0.	0.0	
Brighton x Creveling...	7	0.	0.0	
Eaton as a fertilizer:				
Self-pollinated..........	10	0.	0.0	
Self-pollinated	6	100.	90.0	
Hercules x Eaton.......	5	70.	36.0	
Eldorado as a fertilizer:				
Self-pollinated..........	5	0.	0.0	
Self-pollinated..........	10	0.	0.0	
Self-pollinated	23	0.	0.0	
Self-pollinated.... .. .	4	0.	0.0	
Herbert x Eldorado....	4	0.	0.0	
Brighton x Eldorado ...	4	15.	5.2	
Eumelan as a fertilizer:				
Self-pollinated..........	10	0.	0.0	
Self-pollinated..........	9	0.	0.0	
Self-pollinated..........	3	4.	1.3	
Self-pollinated	1	20.	20.	
Herbert as a fertilizer:				
Self-pollinated.........	2	0.	0.0	
Self-pollinated	5	0.	0.0	
Self pollinated	9	0.	0.0	
Salem x Herbert........	5	0.	0.0	
Eldorado x Herbert.....	5	0.	0.0	
Brighton x Herbert....	4	75.	28.0	
Hercules as a fertilizer:				
Self-pollinated..........	4	0.	0.0	
Self-pollinated..........	10	0.	0.0	
Self-pollinated	1	*	*	
Barry x Hercules.......	5	0.	0.0	

* One good cluster well filled, but all fruits seedless.

TABLE II — *Continued.*

VARIETIES TESTED.	Numbe· of clusters under test.	Highest rating.	Average rating.	Graphic representation of average rating.
Jefferson as a fertilizer:				
Self-pollinated...... ...	3	....	95.0	
Self-pollinated..........	4	100.	75.0	
Self-pollinated	7	60.	39.3	
Brighton x Jefferson....	5	100.	64.0	
Lindley as a fertilizer:				
Self-pollinated..........	10	0.	0.0	
Self-pollinated..........	9	0.	0.0	
Self-pollinated..........	25	0.	0.0	
Self-pollinated..........	25	40.	1.6	
Eldorado x Lindley.....	5	0.	0.0	
Herbert x Lindley	5	0.	0.0	
Salem x Lindley........	5	2.	0.4	
Brighton x Lindley	5	10.	2.0	
Merrimack x Lindley ...	4	98.	32.0	
Merrimack as a fertilizer:				
Self-pollinated...... ...	2	0.	0.0	
Self-pollinated..........	10	0.	0.0	
Self-pollinated..........	23	0.	0.0	
Self-pollinated	3	0.	0.0	
Salem x Merrimack. ...	4	0	0.0	
Lindley x Merrimack ...	3	0.	0.0	
Herbert x Merrimack ...	5	0.	0.0	
Brighton x Merrimack ..	4	100.	25.	
Nectar as a fertilizer:				
Self-pollinated..........	9	4.	....	
Self-pollinated..........	2	100.	0.9	
Brighton x Nectar	5	75.	90.0	
Niagara as a fertilizer:	...	....	40.0	
Self-pollinated....	10	100.	. ..	
Self-pollinated..........	23	100.	75.7	
Self-pollinated..........	12	100.	65.8	
Self-pollinated..........	16	100.	95.1	
Self pollinated	20	100.	93.3	
Aminia x Niagara	1	80.	. ...	
Brighton x Niagara.....	5	100.	52 5	
Brighton x Niagara. ...	9	88.	85.7	
Eldorado x Niagara.....	5	100.	76.	
Lindley x Niagara	5	95.	77.0	
Merrimack x Niagara...	4	100.	96.3	
Salem x Niagara	5	100.	98.0	
Herbert x Niagara	4	100.	98.8	
Rochester as a fertilizer:				
Self-pollinated.........	10	100	100.	
Self-pollinated..........	1	100.	100.	
Brighton x Rochester...	5	100.	72.0	

TABLE II — *Continued.*

VARIETIES TESTED.	Number of clusters under test.	Highest rating.	Average rating.	Graphic representation of average rating.
Salem as a fertilizer:				
Self-pollinated	10	0.	0.0	
Self-pollinated	23	0.	0.0	
Self-pollinated	5	0.	0.0	
Lindley x Salem	5	0.	0.0	
Herbert x Salem	4	0.	0.0	
Brighton x Salem	4	0.	0.0	
Eldorado x Salem	5	2.	0.4	
Merrimack x Salem	5	4.	0.8	
Station 125 as a fertilizer:				
Self-pollinated	10	100.	100.0	
Brighton x Station 125	5	100.	90.0	
Station 146 as a fertilizer:				
Brighton x Station 146	4	60.	21.3	
Station 156 as a fertilizer:				
Brighton x Station 156	4	100.	69.3	
Vergennes as a fertilizer:				
Self-pollinated	10	...	.....	
Self-pollinated	22	90.	44.5	
Self-pollinated	5	40.	24.0	
Self-pollinated	8	90.	77.5	
Self-pollinated	9	95.	45.6	
Brighton x Vergennes	7	100.	53.9	
Worden as a fertilizer:				
Self-pollinated	10	....	...	
Self-pollinated	9	100.	100.	
Self-pollinated	23	100.	96.5	
Self-pollinated	20	100.	94.5	
Self-pollinated	5	90.	84.0	
Self-pollinated	6	100.	95.8	
Self-pollinated	24	100.	93.7	
Self-pollinated	20	100.	96.9	
Black Eagle x Worden	1	0.	0.0	
Eldorado x Worden	5	95.	65.0	
Lindley x Worden	5	100.	70.0	
Brighton x Worden	4	100.	76.0	
Brighton x Worden	8	85.	77.0	
Aminia x Worden	2	88.	88.0	
Salem x Worden	5	100.	89.0	
Merrimack x Worden	4	100.	97.0	
Herbert x Worden	5	100.	97.0	
Wyoming as a fertilizer:				
Self-pollinated	10	0.	0.0	
Self-pollinated	4	4.	1.0	
Self-pollinated	13	*	*	
Self-pollinated	6	90.	21.6	
Brighton x Wyoming	6	2.	0.3	
Aminia x Wyoming	5	20.	4.0	

* But one cluster produced fruit, and that was gathered by grape pickers before it had been rated. Its rating was somewhere between 80 and 100, making the average between 6.1 and 7.7.

By consulting the above table it is seen that Brighton and Wyoming when pollinated with the self-sterile variety, Aminia, were practically sterile and gave no better results than are obtained when they are self-pollinated. Black Eagle succeeded no better than Aminia as a fertilizer. It was tried on the self-sterile varieties, Barry and Eumelan. Brighton was not more effective in fertilizing the self-sterile sorts, Black Eagle, Eldorado, Herbert, Salem, Aminia and Lindley than in fertilizing itself. Slightly better results were obtained when it was tried on Merrimack and Wyoming, but nothing that would encourage the use of Brighton as a fertilizer for self-sterile sorts. Creveling, which is self-sterile, failed to fertilize Brighton. Eldorado, which is self-sterile, gave no results which would encourage its use as a fertilizer for self-sterile sorts, and the same is true of the other self-sterile varieties, Hercules, Herbert, Lindley, Merrimack, Salem and Wyoming. Occasionally the use of a self-sterile variety as a pollinizer for other self-sterile kinds would result in the development of a good cluster as happened when Brighton was pollinated with Merrimack and again with Herbert, but even in such cases failure was the rule rather than the exception.

On the other hand, the use of self-fertile varieties as fertilizers for the self-sterile sorts generally was attended with good results, as may be seen by examining the records of such varieties as Catawba, Worden and Niagara and *Station* 125. When certain varieties which are not strongly self-fertile, were tried as fertilizers for self-sterile sorts they generally succeeded in about the same degree as they commonly do in fertilizing themselves. This point is illustrated in the record of the tests with Eaton, Nectar and Vergennes.

IS FAILURE IN SETTING FRUIT USUALLY DUE TO IMPERFECT PISTILS OR TO IMPERFECT OR IMPOTENT POLLEN?

It is instructive to study the results of these investigations with reference to their bearing upon the question whether the failure to set fruit which has been observed among the self-sterile and the imperfectly self-fertile varieties may generally be attributed to weakness of the pistils or to imperfect or impotent pollen. In

order to facilitate the study of the evidence on this point, which was obtained in the 1899 investigation, the data are arranged in Table III so as to show in each case the results which follow the use of various kinds of pollen upon the pistils of one variety.

TABLE III.— COMPARATIVE FRUITAGE OF GRAPES FROM USING THE POLLEN OF DIFFERENT VARIETIES UPON THE SAME SELF-STERILE VARIETIES.

Varieties Tested.	Number of Clusters under test.	Highest rating.	Average rating.
Aminia,[1] pollinated by:			
Brighton	6	10.	1.7
Wyoming	5	20.	4.0
Niagara	1	80.	80.0
Worden	2	88.	88.0
Catawba	4	90.	89.0
Barry,[2] pollinated by:			
Barry	2	0.	0.0
Barry	10	0.	0.0
Barry	8	0.	0.0
Black Eagle	0	0.	0.0
Hercules	5	0.	0.0
Black Eagle,[3] pollinated by:			
Brighton[4]	4	0.	0.0
Worden[4]	1	0.	0.0
Brighton,[5] pollinated by:			
Creveling	7	0.	0.0
Salem	4	0.	0.0
Aminia	7	2.	0.3
Wyoming	6	2.	0.3
Lindley	4	10.	2.0
Eldorado	5	15.	5.2
Station 146	4	60.	21.3
Merrimack	4	100.	25.0

Varieties tested.	Number of clusters under test.	Highest rating.	Average rating.
Brighton, pollinated by:			
Herbert	4	75.	28.0
Nectar	5	75.	40.0
Vergennes	7	100.	53.9
Jefferson	5	100.	64.0
Station 156	4	100.	69.3
Rochester	5	100.	72.0
Catawba	8	95.	74.4
Catawba	5	100.	80.0
Worden	4	100.	76.0
Worden	8	85.	77.0
Niagara	5	100.	52.5
Niagara	9	88.	85.7
Station 125	5	100.	90.0
Eldorado,[6] pollinated by:			
Brighton	5	0.	0.0
Herbert	5	0.	0.0
Lindley	5	0.	0.0
Salem	5	2.	0.4
Catawba	4	2.	0.5
Worden	5	95.	65.0
Niagara	5	100.	76.0
Eumelan,[7] pollinated by:			
Black Eagle	2	0.	0.0

[1] For results from self-pollinated Aminia, see page 386.

[2] The clusters of Barry which were open to cross-pollination in a mixed vineyard, were finely formed and well developed. This was true of the vine on which the tests with Black Eagle and Hercules were made.

[3] The summary of results with Black Eagle self-pollinated are given on page 386.

[4] On the vine which was used for these tests, the clusters of Black Eagle which were open to cross-pollination, were often well filled, yet many were quite imperfectly filled.

[5] The records of self-pollinated Brighton are summarized on page 386.

[6] The records of self-pollinated Eldorado are summarized on page 387.

[7] The records of self-pollinated Eumelan are summarized on page 387.

TABLE III — *Continued.*

Varieties tested.	Number of clusters under test.	Highest rating.	Average rating.	Varieties Tested.	Number of clusters under test.	Highest rating.	Average rating.
Herbert,[8] pollinated by:				Merrimack,[11] pollinated by:			
Brighton	1	0.	0.0	Salem	5	4.	0.8
Eldorado	4	0.	0.0	Brighton	4	35.	8.8
Lindley	5	0.	0.0	Lindley	4	98.	32.0
Merrimack	5	0.	0.0	Catawba	3	95.	91.7
Salem	4	0.	0.0	Niagara	4	100.	96.3
Worden	5	100.	97.0	Worden	4	100.	97.0
Niagara	4	100.	98.8	Salem,[12] pollinated by:			
Catawba	2	100.	100.0	Brighton	3	0.	0.0
Hercules,[9] pollinated by:				Herbert	5	0.	0.0
Brighton	2	*	*	Merrimack	4	0.	0.0
Columbian Imperial	5	50.	36.0	Lindley	5	2.	0.4
Eaton	5	75.	36.0	Catawba	1	4.	4.0
Lindley,[10] pollinated by:				Worden	5	100.	89.0
Merrimack	3	0.	0.0	Niagara	5	100.	98.0
Salem	5	0.	0.0	Wyoming,[13] pollinated by:			
Brighton	3	12.	4.0	Aminia	4	8.	2.0
Catawba	5	95.	63.0	Brighton	6	50.	12.0
Worden	5	100.	70.0	Catawba	1	100.	100.0
Niagara	5	95.	77.0				

An examination of the results which are summarized in Table III, shows that Aminia gave scarcely any fruit when fertilized with the imperfectly self-fertile sorts, Brighton and Wyoming, but fruited freely when fertilized with the self-fertile sorts, Niagara, Worden and Catawba. Barry gave no fruit when pollinated with either Black Eagle or Hercules, but clusters which were open to cross-pollination in a mixed vineyard, were well-filled with fruit.

[8] The records of self-pollinated Herbert are summarized on page 387.
[9] The records of self-pollinated Hercules are summarized on page 387.
[10] The records of self-pollinated Lindley are summarized on page 388.
[11] The records of self-pollinated Merrimack are summarized on page 388.
[12] The records of self-pollinated Salem are summarized on page 389.
[13] The records of self-pollinating Wyoming are summarized on page 389.

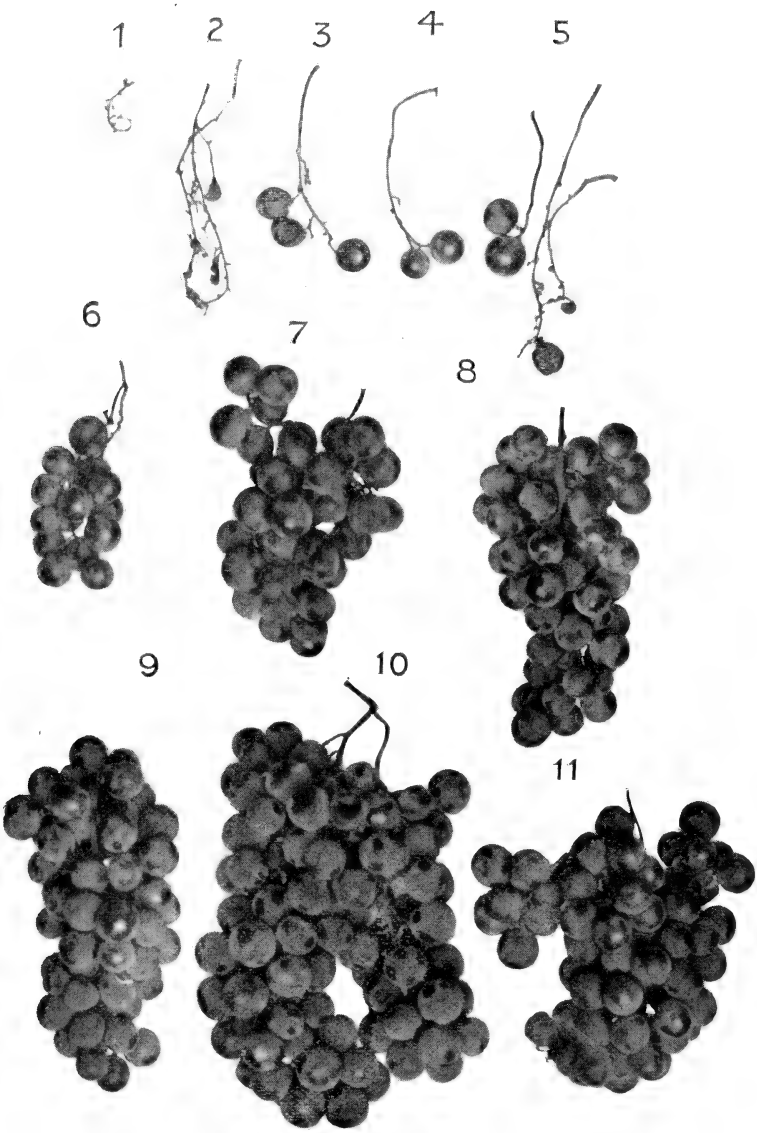

PLATE XXXIV.—BRIGHTON FERTILIZED BY DIFFERENT VARIETIES.

1. BY SALEM. 2. BY CREVELING. 3. BY LINDLEY. 4. BY BRIGHTON. 5. SELF-POLLINATED. 6. BY NECTAR. 7. BY JEFFERSON. 8. BY NIAGARA. 9. BY WORDEN. 10. BY VERGENNES. 11. BY ROCHESTER.

Brighton gave little fruit or none when fertilized with the self-sterile or imperfectly self-fertile kinds, Creveling, Salem, Aminia, Wyoming, Lindley, Eldorado, Merrimack and Herbert. The use of varieties having a higher degree of self-fertility gave correspondingly better results as is shown in the records of Nectar, Vergennes and Jefferson, while the use of strongly self-fertile kinds for fertilizers gave more perfect clusters of fruit as is shown by the records of Rochester, Catawba, Worden, Niagara and *Station* 125.

Results corresponding to those given above were obtained with the different classes of varieties which were tried as fertilizers on Eldorado, Eumelan, Herbert, Hercules, Lindley, Merrimack, Salem and Wyoming. So far as these tests are concerned, they support the theory that the failure of self-sterile or imperfectly self-fertile grapes in setting fruit is not generally due to imperfect development of the pistils because when they are supplied with pollen from strongly self-fertile grapes they set fruit abundantly. It has been observed that blossom buds of certain varieties may in some cases drop off before the flowers open. It has also been observed that when the vines are not in good condition certain varieties which generally produce well-filled clusters of perfect fruit may have a large proportion of imperfect clusters. It appears, therefore, that failure in setting fruit may be due to various causes, prominent among which is the lack of proper pollination.

GRAPES CLASSIFIED ACCORDING TO THEIR BLOOMING SEASON.

In selecting varieties of grapes to be used as fertilizers for those kinds which are either self-sterile or imperfectly self-fertile, it seems desirable to chose not only strongly self-fertile kinds, but also kinds which come into blossom at the same time with those which they are expected to fertilize. The following lists have been arranged to show approximately the comparative season of blooming of the different varieties of grapes. The arrange-

ment is based upon the records for a series of years of the blooming season of the varieties in the Station vineyards. A large part of these records for the varieties named below were published in Bulletin 157. In making the following lists the records for 1899 are also taken under consideration, and accordingly they do not exactly correspond with those which were published in the popular edition of Bulletin 157. The lists are arranged to show in parallel columns the strongly self-fertile kinds on the one hand, and on the other the imperfectly self-fertile and the self-sterile kinds. In all tests which have been made as to their self-fertility, when the vines were in normal condition, the former have on the average given marketable clusters, while the latter have given on the average either imperfectly filled clusters or none.

In grouping the varieties so as to show their relative blooming season they have been classed as "very early," "medium early," "mid-season," "medium late," "late" and "very late." These lists do not show the relative season of ripening.[14] There is no marked line of separation between the groups below. Many of the varieties extend their period of blooming into the period of the next later group, so that it is not always necessary, in arranging the varieties for planting, to follow the classification rigidly.

TABLE IV.— GRAPES CLASSIFIED ACCORDING TO THEIR BLOOMING SEASON.

[This table shows in parallel columns lists of grapes which bloom at approximately the same time. The names of strongly self-fertile kinds appear on the left, and those of imperfectly self-fertile and self-sterile kinds, on the right.]

STRONGLY SELF-FERTILE.	SELF-STERILE AND IMPERFECTLY SELF-FERTILE.
BLOOM VERY EARLY.	
Clinton.	Clevener.
Janesville.	Marion.
Mary Favorite.	

14 After Bulletin 157 was issued, several inquiries came to the Station, which showed that some readers supposed that the lists therein given to show the season of blooming, also indicated the relative time of ripening, but such is not the case. Some of the very earliest in blooming, as, for example, the Clinton, are late in ripening.

Table IV.— *Continued.*

Strongly self-fertile.	Self-sterile and imperfectly self-fertile.
Bloom medium early.	
Bell.	Beagle.
Berckmans.	Elvibach.
Brown.	Faith.
Canada.	Helen Keller.
Caywood, No. 50.	Noah.
Champion.	Pearl.
Cottage.	White Jewel.
Early Market.	Woodruff.
Elvira.	
Etta.	
Eumedel.	
Kensington.	
Lucile.	
Lutie.	
Perkins.	
Presley.	
Ulster.	
Bloom mid-season.	
Alice.	Adirondack.
Ambrosia.	Alexander Winter.
Antoinette.	Amber.
Arkansaw.	Amber Queen.
Bertha.	Aminia.
Chandler.	Barry.
Chautauqua.	Creveling.
Colerain.	Daisy.
Columbian Imperial.	Dracut Amber.
Concord.	Eumelan.
Diana.	Grein Golden.
Early Ohio.	Herbert.
Early Victor.	Hercules.
Esther.	Jewel.
Glenfeld.	Juno.
Golden Grain.	Lindley.
Hartford.	Maxatawney.
Herald.	Merrimack.
Highland.	Montefiore.
Isabella.	Northern Muscadine.
Isabella Seedling.	Red Bird.
Jessica.	*Rogers* No. 5.
Lady.	Salem.
Lady Washington.	*Thompson* No. 5.

TABLE IV.— *Continued.*

BLOOM MID-SEASON — *Continued.*

STRONGLY SELF-FERTILE.	SELF-STERILE AND IMPERFECTLY SELF-FERTILE.
Leavenworth.	Vergennes.
Lindmar.	Wilder.
Little Blue.	Wyoming.
Mabel.	
Martha.	
Missouri Riessling.	
Monroe.	
Mills.	
Moore Early.	
Niagara.	
Pocklington.	
Prentiss.	
Profitable.	
Rochester.	
Rockwood.	
Rogers No. 13.	
Rogers No. 24.	
Rogers No. 32.	
Shelby.	
Shull No. 2.	
Standard.	
Superb.	
Telegraph.	
Victoria.	
Winchell.	
Worden.	

BLOOM MEDIUM LATE.

Agawam.	Aledo.
Brilliant.	Black Eagle.
Catawba.	Blanco.
Centennial.	Brighton.
Delaware.	Burnet.
Diamond.	Canonicus.
Duchess.	Denison.
Edmeston No. 1.	Eldorado.
Empire State.	Essex.
Hopican.	Gærtner.
Illinois City.	Geneva.
Iona.	Gold Dust.
Leader.	Hayes.
Livingston.	Massasoit.
Marvin Seedling.	Norwood.
Mathilde.	Oneida.

Table IV — *Concluded.*

BLOOM MEDIUM LATE — *Continued.*

STRONGLY SELF-FERTILE.	SELF-STERILE AND IMPERFECTLY SELF-FERTILE.
Olita.	Red Eagle.
Paradox.	Requa.
Paragon.	Roenbeck.
Poughkeepsie.	Roscoe.
Rommel.	Rustler.
Rutland.	*Thompson* No. 7.
Wheaton.	
Witt.	

BLOOM LATE.

Big B. Con.	America.
Collier (Dr.).	Hexamer (Dr.).
Croton.	
Early Golden.	
Jefferson.	
Metternich.	
Norton.	
Opal.	
Senasqua.	
Triumph.	

BLOOM VERY LATE.

Bailey.	Big Hope.
Big Extra.	
Carman.	
Elsinburg.	
Fern Munson.	
Hopkins.	

COMMON DISEASES AND INSECTS INJURIOUS TO FRUITS.*

S. A. BEACH, V. H. LOWE AND F. C. STEWART.

INTRODUCTION.

The purpose of this bulletin is to furnish the fruit-grower with a concise account of the common diseases and insects most injurious to cultivated fruits in New York State and to present up-to-date directions for fighting them most efficiently and economically. The accompanying index makes it easy to find any subject treated in the bulletin.

The preparation of spray mixtures and the apparatus for applying them are not treated here because they are discussed at length in Bulletin 121 and its appendix. Both Bulletin 121 and this bulletin should be preserved for reference.

The various fruits are taken up in alphabetical order and under each one the diseases are first considered, then the insects. In the consideration of each particular disease or insect, it is the general plan of the bulletin to give first, one or more descriptive paragraphs setting forth its general appearance, the chief features of its life-history and its economic importance. Then follows a statement of the remedial or preventive treatment which is recommended or suggested by the authors. Where nothing can be positively recommended, suggestions are made, pointing out what appears to be the most promising line of treatment. Recommendations quoted from other authors are given on their authority.

In some instances it is possible to combat various diseases and insects with one general line of treatment. In such cases the

* Reprint of Bulletin No. 170.

general treatment which is advocated is stated after the several diseases and insects have received individual consideration.

APPLE DISEASES.

APPLE TREE CANKER.

(*Sphaeropsis malorum* Pk.)

The term canker, as applied to diseases of trees, is used to designate an injury that destroys the bark and lays bare portions of wood. It has been discovered that a canker which is doing serious damage to apple orchards of this State, is caused by the fungus, *Sphaeropsis malorum* Pk. This is the same fungus that causes the black rot of apple, pear and quince fruit. The disease usually attacks the larger limbs where it may be detected by the swollen appearance of the limbs, the rough, black bark, and in many instances bare wood, black and decaying. The area of bare wood is, in many instances, not large, but the extent of rough, swollen bark may be several feet. The wounds and unhealthy bark interfere with the circulation of the sap and where a majority of the limbs are attacked the tree is greatly enfeebled and may die from the effects.

Some varieties, as the Esopus Spitzenburg and Twenty Ounce, are very susceptible to the attacks of this fungus, and many other common sorts are by no means exempt.

Treatment.— No experiments in treating this disease have, as yet, been completed; therefore, no definite line of treatment can be given. The following suggestions are based on observations and studies of the disease as it occurs in a large number of orchards: (1) Remove all diseased limbs wherever practicable. (2) When spraying with Bordeaux mixture for apple scab pay special attention to coating the limbs with the mixture as well as the leaves and fruit. An earlier treatment given when the leaf-buds are beginning to open may also be advisable. (3) In some instances it will probably pay to scrape or cut the diseased bark from the canker spots and scrape the rough bark from other por-

tions of the tree. The trunk and larger limbs may then be washed with thick Bordeaux mixture or with one of the washes that are recommended for this purpose. The following formula is given as a type of these washes, as it contains the important ingredients:

WASH FOR TREE TRUNKS.

Whale oil soap	1 pint.
Slaked lime	3 pints.
Water	4 gallons.
Wood ashes	To thicken as desired.

Dissolve the soap in hot water, then stir in the lime. When the ingredients have been reduced to a smooth state by stirring, dilute with water to four gallons, then stir in wood ashes till the wash is of the desired consistency.

FIRE BLIGHT.

The same as the "Fire Blight of the Pear" discussed on page 443.

FLY SPECK.

(*Leptothyrium pomi* (Mont. & Fr.) Sacc.)

This disease, although commonly associated with sooty blotch, on both apples and pears, is probably distinct from it. It appears as groups of black dots resembling large fly specks. The specks are not caused by any insect but by a fungus which, like the sooty blotch fungus, is confined exclusively to the surface of the fruit.

The treatment for fly speck is the same as for sooty blotch. See page 405.

LEAF-SPOT.

(*Phyllosticta* spp.)

Description.—This disease is caused by two very closely related species of fungi. It attacks only the foliage. Very soon after the buds break, the young leaves show small, reddish-brown spots. As the leaves grow, the spots enlarge. When the leaves are full grown the spots are brown, brittle, circular, with sharply defined outline, and vary in diameter from one-twelfth to one-fourth of

an inch. In July, several black specks of the size of a small pin head appear at the center of some of the spots, on the upper side of the leaf. Many spots, however, never show the black specks.

Affected leaves fall prematurely. In severe attacks the trees may be almost completely defoliated by July 1. The disease is most troublesome in wet seasons. It is more prevalent on Long Island and in the Hudson Valley than in other parts of the State.

Treatment.— Leaf-spot is only partially prevented by the treatment recommended for scab. See page 404. Where the disease is troublesome we suggest that this treatment be preceded by a spraying with Bordeaux mixture (1-to-11 formula) just as the buds show green at the tips.

RUST.

(*Gymnosporangium* spp. Syn. *Roestelia* spp.)

Description, etc.— Rust is a disease in which circular, orange-colored spots about one-fourth of an inch in diameter appear on the leaves in June. It also produces yellow spots on the fruit at about the same time.

It may be caused by several species of fungi belonging to the genus *Gymnosporangium.* The species of this genus are peculiar in that in one stage of their life cycle they live upon the apple and some other closely related plants, while in another stage they inhabit the red cedar and its relatives. *Gymnosporangium macropus* is the most common cause of apple rust. Its other stage occurs on the red cedar where it produces the so-called cedar apples.

In New England and some parts of the South apple rust is a destructive disease, but in New York it is of rare occurrence except on Long Island. Some varieties are attacked much more severely than others. Rust should not be confused with russeting.

Treatment.— Rust is difficult to combat. Spraying seems to check it but little. Since the red cedar harbors one stage of the fungus which is the chief cause of rust, it is good policy to destroy, so far as practicable, all red cedars in the vicinity of the orchard.

RUSSETING AND BELTING OF FRUIT.

Description.— Both apples and pears are subject to a trouble known as russeting or belting. It is sometimes also called rust, but this name is objectionable because it leads to confusion with the true apple rust discussed above which is a very different thing.

Fruits entirely sound and perfect in form may show areas on which the skin is rough, brown and corky. These areas may be irregular in outline, in which case the fruit is said to be russeted, or they may form a definite zone around the fruit producing the condition known as belting.

Cause.— This trouble is not caused by any insect or fungus. It is due to some irritation of the skin of the fruit, and may be brought about in three principal ways:

(1) By the occurrence of long continued cloudy, wet weather immediately after the setting of the fruit;

(2) By spraying with Bordeaux mixture during cloudy, wet weather;

(3) By the freezing of dew on the fruit while it is young and tender. In this case the injured area usually takes the form of a zone or belt.

No remedy is known.

SCAB.

(*Venturia inæqualis* (Cke.) Aderh.[1])

Description.— The worst disease with which the apple growers of this State have to contend is one commonly known as "apple scab" or "cracking of the apple." It is caused by a fungus which attacks the skin of both foliage and fruit.

On the fruit the spots at first usually circular in outline and have a very dark velvety-green surface, but afterwards they become nearly or quite black. In some cases the diseased tissue finally scales off leaving a scar with a corky, russet surface. The

[1] This is the name given to the ascosporic stage of *Fusicladium dendriticum* (Wallr.) Fckl.

spots vary in size from small dots to the large irregular patches which are formed when two or more smaller spots coalesce. Where the spots are large the fruit may become one sided or otherwise distorted, and often it cracks open. For this reason the disease is sometimes called "the cracking of the apple."

On the leaves the fungus has the appearance of a dark mold. It is found in spots on both the upper and under surfaces. The disease may cause the leaves to be much crumpled and finally show brown, dead tissue which breaks away leaving the foliage torn and ragged, or the entire leaf may drop off.

Some varieties are especially susceptible to its attacks, and it is not unusual to see a very large proportion of their fruit badly cracked by it. On the other hand, there are varieties which are generally quite resistant, on which the scab spots increase comparatively slowly, and the cracking of the fruit is seldom or never seen.

On the fallen leaves of the previous season, there develop, in the spring, perithecia within which are perfected spores for the propagation of the fungus.[2] The fungus is known to begin its attacks very early in the season, for occasionally it may develop sufficiently to be discovered by the naked eye on unopened blossom buds. In seasons especially favorable to its early development it has been observed to cause great injury early in the season, destroying the blossoms and the young fruit. In order to control the disease, therefore, it is important to begin treatment early. It must be borne in mind that the treatment is effective by preventing the germination of the spores rather than by killing the fungus after it has become established either on the foliage or on the fruit.

Treatment.— The scab may be controlled by proper spraying with Bordeaux mixture. Fortunately these treatments may be combined with others which are advocated by the Entomologist

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2 Aderhold, Dr. Rud. Die Fusicladien unserer Obstbäume, I. Theil Landw. Jahrbücher, 25: 880–914, 1896.

against the case-bearers, bud moth, canker worm, codling moth and other injurious insects. The combined treatment advocated for scab, leaf-spot, canker-disease, codling moth, canker worms, and various other insects is given on page 417. As there stated, the scab may generally be controlled by three applications of the Bordeaux mixture if made at the proper time, and very thoroughly. Where but three treatments are given, the first spraying should be made after the buds break but before the blossoms open; the second, just after the blossoms fall; and the third, from ten to fourteen days after the second.

Winter treatment for apple scab.— Spraying for apple scab while the buds are dormant has not been found profitable. The later treatments advocated above *must* be made in order to control the disease. When these are made the winter treatment does not bring sufficient additional benefit to justify the expense of making it against the scab alone, but it may pay when directed also against the canker disease and combined with some application which must be made against insects such as case-bearers or bud moth.

It is known that the scab fungus lives during winter on the fallen leaves and in the spring produces spores by means of which it spreads to the new foliage. Probably it may exist during winter to some extent on the bark of young twigs, also. Granting that this is the case and that a large part of the fungus on the tree is killed by winter treatment, which is improbable, it is evident that when the new foliage appears it must be covered with some fungicide to protect it from the spores produced on the fallen leaves. The fruit grower should direct his efforts toward preventing the germination of the fungus spores on the foliage, rather than attempt to kill the fungus in winter quarters. The Bordeaux mixture treatment is a preventive rather than a cure.

SCALD.

Stored fruit of some varieties of apples, notably Rhode Island Greening, sometimes becomes discolored and presents an appear-

ance which is commonly called "scald." It is not caused by any fungus. Jones[3] has made some investigations concerning the cause of scald. The following account is based on his reports.

Description.— The scald first appears as a light brownish tinge of the skin either in fairly well defined spots or more or less diffused. The discolored areas enlarge with more or less rapidity coalescing until the entire surface of the apple may be involved. At the same time the color changes from a lighter to a darker brown shade and usually terminates in a black rot. At the beginning of the trouble the flesh appears sound, the discoloration involving only the outer cells of the fruit. Afterwards, the flesh also becomes discolored and is finally invaded, in most cases, by some fungus, but the primary cause of the scald cannot be attributed to any fungus or other parasite.

It appears certain that the primary cause of the scald is to be found in climatic and orchard conditions, the conditions of the storehouse being secondary. The fruit which is grown and matured under favorable conditions can be carried through the normal season of keeping for fruit of that variety without the appearance of the scald. If grown under unfavorable conditions the fruit requires very careful attention to the temperature and perhaps other store-room conditions if it is kept for any length of time without scalding.

SOOTY BLOTCH.

(*Phyllachora pomigena* (Schw.) Sacc.)

Description, etc.—In wet seasons and especially in damp, shady situations, apples are subject to the attacks of the fungus which causes sooty blotches on the fruit. These blotches are sooty-black, circular, and measure from one-fourth to one-half an inch in diameter. Frequently the blotches coalesce, giving the fruit a sooty, dirty appearance.

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[3] Jones, L. R. Vt. Agr. Exp. Sta. Ann. Rept. 1896–1897: 55–59 and 1897–1898: 198.

Sooty blotch is sometimes mistaken for scab. A striking point of difference between the two diseases is the manner in which they attack the fruit. Sooty blotch is confined to the surface of the fruit and may be readily removed by rubbing, while the scab destroys the cuticle (outer layer of the skin) thus making a spot which cannot be removed by rubbing.

Being superficial in its growth, the fungus does the fruit no harm except to make it unsightly and, consequently, less salable.

Under favorable conditions sooty blotch may appear upon almost any variety, but it seems to have a preference for some of the fair skinned varieties such as Bellflower, Fall Pippin and Rhode Island Greening. Pears, also, are subject to it.

Treatment.— In orchards sprayed for apple scab the fruit will not, ordinarily, suffer much either from sooty blotch or the fly speck disease. However, for the best results with both of these diseases it seems necessary to make one or two sprayings in July in addition to those made in treating apple scab.

APPLE INSECTS.

BORERS.

Several species of borers attack the apple tree. As a rule they will be found in the trunk, but occasionally in the larger limbs. A small species sometimes infests the twigs. The presence of the grubs is usually indicated by the discolored bark and by their castings. The following species are most commonly met with in this State:

THE FLAT-HEADED APPLE-TREE BORER.

(*Chrysobothris femorata* Fab.)

Description.— The female beetle lays its eggs in the bark late in June or in July. These hatch in a few days and the grubs at once gnaw their way into the sap-wood where they live and feed from one to three years before reaching full size. A short time before pupation they go deeper into the solid wood. The adults

are steel-colored beetles, flattened above and with irregular depressions on the wing covers.

Treatment.— The trees should be examined at least once a year and the borers dug out with a knife or killed by inserting a flexible wire into the burrows.

THE ROUND-HEADED APPLE-TREE BORER.

(*Saperda candida* Fab.)

Description.— The life-history of this species is similar to that of the preceding except that the grub requires but about a year to reach full growth. In both the grub and adult stages the body is more nearly cylindrical in outline. The adult is prominently marked by two broad, nearly parallel, white lines extending the full length of the body.

Treatment.— The same as for the preceding species.

LEAF-EATING INSECTS.

THE APPLE-TREE TENT CATERPILLAR.

(*Clisiocampa americana* Harr.)

Description.—This tent caterpillar feeds upon a variety of fruit and other trees and is especially injurious to the apple. The eggs are laid in July in conspicuous brown rings or masses about the smaller twigs. The caterpillar is developed in the egg in the fall but does not emerge from the egg shell till early in the following spring. The caterpillars from each egg mass form a colony and spin a tent in which they stay when they are not feeding on the leaves of the tree.

After they are full grown, that is about five or six weeks after hatching, they spin their cocoons. The adults, which are brown moths, with two, oblique, parallel white lines on the fore wings, emerge in the latter part of June or early in July.

Treatment.— The egg masses may easily be gathered in winter and burned. The caterpillars may be destroyed while in their

nests or by applying a poisonous spray to the foliage. It is easier to kill the caterpillars by spraying when they are very small than it after they have become large. It is important, therefore, to make the first spraying just before the blossoms open because that is about the time the caterpillars emerge from the egg. The cocoons are quite conspicuous and their destruction will aid materially in lessening the numbers of females to lay eggs.

For further information relative to these insects and their near relatives, the forest tent-caterpillars, which are sometimes injurious in orchards, consult Bulletins 152 and 159 of this Station.

BUD MOTH.

(*Tmetocera ocellana* Schif.)

Description and life-history.— The young of the bud moth are small brown caterpillars about half an inch in length. During the winter they live in small, oval, silken cases, attached firmly to the bark of the twig. As the caterpillars are very small when winter sets in, about one-eighth of an inch in length, their silken cases are also small and hence easily overlooked. During this period of their lives the caterpillars are green in color.

About the time that the buds begin to swell in the spring, the caterpillars come forth and bore into them, thus early protecting themselves against insecticides. As the young leaves and flowers unfold the caterpillars form nests for themselves by tying the leaves together, making their presence quite conspicuous. They do not leave these nests in feeding. During June they reach full growth and change to the chrysalis stage in the nest. In about ten days a small brown moth escapes. This is the adult. The eggs are laid on the under side of the leaves. These soon hatch and the young caterpillars feed on the under sides of the leaves, protecting themselves by a thin, silken web. Before winter approaches they migrate to the twigs and form the silken cases in which, as above stated, they live over winter.

Treatment.— The only available time for effective treatment is just before the buds begin to swell, the object being to cover the buds with poison so that the young caterpillars will be poisoned as they gnaw into the bud. To make the work thorough, two applications will usually be required. Paris green or some other good arsenical should be used. If it is desired to treat the trees for apple scab, Bordeaux mixture may be combined with the Paris green for either of the above treatments. See page 417.

CASE BEARERS.

PISTOL-CASE-BEARER.[4]	CIGAR-CASE-BEARER.
(*Coleophora malivorella* Riley.)	(*Coleophora fletcherella* Fern.)

During the past three or four years these two insects have become very troublesome in this State. Their principal food plant is the apple, but they also feed upon the pear and quince and probably other fruit trees. The life histories of the two species are very similar. That of the pistol-case-bearer is as follows:

Descriptions and life history.—The young caterpillars live over winter in little pistol-shaped cases of silk which are attached on end to the twigs usually near and sometimes upon the buds. These cases measure about one-eighth of an inch in length and resemble the bark in color. The winter cases of the cigar-case-bearer are more flattened laterally and are somewhat crescent shaped. They are also lighter in color and are more frequently found in sheltered places in the angles of the twigs.

Early in the spring, a short time before the leaf buds burst, the hibernating case-bearers become active. They attack the growing buds gnawing through the outer covering to feed on the tender tissues beneath. Later in the season they feed on the young leaves making small round holes through the cuticle and feeding, in much the same manner as a true leaf miner, on the softer tissues beneath. In doing this the caterpillars do not usually leave their cases but reach out as far as necessary. As they

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[4] This species is discussed in detail by Lowe, in Bulletin 122 of this Station.

become larger and stronger they devour the entire leaf with the exception of the midrib and large veins. They also attack the flower buds, flowers and fruit.

About the middle of May the case bearers have become full grown and are ready to pupate. They have enlarged their houses as their growing bodies demanded until now the cases measure about one-fourth of an inch in length. The case-bearers migrate to the twigs and attach their homes firmly on end to the bark. Before the transformation to the pupa stage takes place the caterpillars turn around in their cases so that their heads are toward the upper or curved ends. The pupa stage lasts about two weeks.

The principal difference in appearance between these two species is apparent at this time. The case of the cigar-case-bearer is straight and closely resembles a miniature cigar; while, as previously stated, that of the pistol-case-bearer slightly resembles an old fashioned pistol.

The adults of both species are moths measuring about half an inch from tip to tip when the wings are spread. The color of the former is steel gray, the latter is marked with brown. The moths appear during the latter part of May or early in June. The eggs of both species are deposited singly on the under sides of the leaves. They hatch in about ten days or two weeks. The young caterpillars feed on the tender pulp of the leaf. During September they migrate to the smaller branches and twigs, to remain until spring. Thus there is but one annual generation.

Treatment.— For general treatment advocated against these insects see page 417. The first treatment is of especial importance, the object being to have the buds coated with poison so that the first meal of the little caterpillars will be a poisoned one. A second application may be made just as the leaves unfold and a third if needed.

CANKER WORMS.

Although there are several species of canker worms quite common to the apple orchards of the State there are but two species

that often occur in sufficient numbers to do serious injury. These are the spring canker worm (*Paleacrita vernata* Peck) and the fall canker worm (*Anisopteryx pometaria* Harr.) The former is the more common and injurious of the two. The life histories of the two species are very similar except that the eggs of the spring canker worm are laid in the spring and those of the fall canker worm in the fall. The eggs of both species hatch in the spring about the time the leaf buds are unfolding.

Descriptions.— The eggs of the former species are placed somewhat promiscuously in sheltered places on the twigs. They are small oval eggs and the shell has a brilliant pearly luster. The eggs of the latter species are placed on end side by side in quite regular masses. They are somewhat cylindrical but smaller at the base and flattened at each end.

When first hatched the caterpillars of both species are very small and of a light green color. They devour the leaves rapidly. When disturbed they will drop, suspending themselves by silken threads. When mature they are about an inch long and vary in color from light green to darker shades. When ready to pupate they go into the ground, where the cocoon is spun and the chrysalis formed. Most of the spring canker worms remain in the ground until the first warm days of the following spring, but those of the other species come out of the ground in the fall. The adults of both species are moths. The females are wingless and the males winged.

Treatment.— There are two principal methods of combating these insects. First the females may be trapped while endeavoring to ascend the trunk of the tree. Numerous traps have been tested including bands of tin, cloth, waste wool, tarred paper and certain chemical preparations. Several patent metal devices for trapping the moths have been put upon the market recently. The most important point in connection with the use of traps in general is to put them on early in the season. It is usually advisable to put the metal traps in place early in the fall to catch the

moths of the fall canker worm. They will then be in place for the earliest moths of the spring species.

Second, the caterpillars may be successfully combated by spraying the trees with Paris green or some other equally effective arsenical insecticide. See page 417. Two and occasionally three applications are usually necessary. Make the first application just as the young leaves are unfolding, and the second about a week later.

Regular annual spraying with a good arsenical compound is especially important in this case. Orchards thus treated are not as likely to become seriously infested with these and other leaf eating insects as the orchards which are sprayed irregularly or not at all.

FRUIT INSECTS.

CODLING MOTH.

(*Carpocapsa pomonella* Linn.)

Descriptions.— This is the insect that causes "wormy" apples. The recent investigations of Washburn, Card and Slingerland have thrown new light on certain stages of its life-history. It is now known that the eggs, which are whitish, oval discs, may be laid promiscuously upon the fruit or even upon the twigs and leaves. It is probable that they are not laid until after the blossoms have fallen. The period of incubation is about a week.

According to Slingerland[5] about 75 per ct. of the caterpillars enter the fruit at the blossom end. The caterpillars of the second brood often enter on the side of the fruit. They are full grown in twenty to thirty days. When once within the fruit they usually remain until ready to pupate. The cocoons are made in any convenient, protected place, as under the loose bark of the trunk or larger branches of the tree, or in near-by rubbish. Some of the caterpillars remain in the cocoons over winter, while others soon transform to the pupa stage forming a more or less complete sec-

[5] Cornell Univ. Agr. Exp. Sta. Bul. 142: 21.

ond brood. These are sometimes very abundant in late summer and in autumn. The adult is a small brown moth measuring about $\frac{3}{4}$ of an inch from tip to tip when the wings are spread.

Those who wish an exhaustive treatise on this insect should consult Prof. Slingerland's bulletin.[6]

Treatment.—A considerable percentage of the worms can be killed by spraying within the first week after the blossoms have fallen. The calyx end of the fruit must be filled with the poison before the calyx lobes close, hence much pains should be taken to make at least one thorough application before that occurs.

GREEN FRUIT WORMS.

(*Xylina* sp.[7])

Descriptions.— These insects sometimes do serious injury by eating into the young apples. They also attack pears, plums, peaches and quinces. The full-grown caterpillars measure from an inch to nearly an inch and a half in length. They are green or yellowish green in color with various irregular markings and stripes, the most prominent of the latter being a narrow, cream-colored one down the middle of the back and a wider one along each side.

The caterpillars are most abundant during May, soon after the fruit has formed. They continue feeding until about the middle of June. They feed mostly at night, resting on the under sides of the leaves during the day. When full grown they go into the ground, form a rough cocoon and pupate. The adults, which are dull-colored moths measuring about two inches from tip to tip with the wings spread, come forth in the fall and remain over winter in some sheltered place, laying their eggs in the spring.

Treatment.— These insects have proven difficult to control. Experiments by Lowe with Paris green, one pound to 100 gallons of water, applied to the infested trees when the caterpillars

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6 Loc. cit.

7 For a more complete account of these insects, see Cornell Univ. Agr. Exp. Sta. Bul. No. 123, by M. V. Slingerland.

were about half grown, gave very unsatisfactory results. It is not improbable, however, that had the experiments been made earlier while the caterpillars were small the poison would have had more effect. Where practical, as in the case of small trees, the caterpillars may be jarred off in the same manner as the plum curculio.

MAGGOT.

(*Rhagoletis pomonella* Walsh.)

Description.— This insect is popularly known as the "apple maggot" or "railroad worm." It is one of the most important species that attacks the fruit. Its life-history has been fully worked out by Dr. F. L. Harvey.[8] The adult insects are two-winged flies. They appear in June. The female punctures the skin of the fruit with her sharp ovipositor and lays her eggs just beneath. In a few days the eggs hatch into white maggots which make numerous irregular channels in the pulp of the apple, enlarging them as the maggots increase in size. This injury often does not show on the outside, and hence infested fruit may be harvested and unintentionally sold as good. Badly infested fruit usually falls early.

The maggots leave the fallen fruit and enter the ground to pupate, remaining until the following spring before emerging as adults.

The apple maggot appears to be spreading in this State, and as it is capable of doing great injury it should be carefully watched for and promptly checked when found.

Treatment.— This insect has proven a difficult one to control. as the maggots work only within the fruit spraying the trees will have no effect. Probably the most practical remedy is the immediate destruction of the windfalls in infested orchards. This may be conveniently done by allowing hogs and sheep to run in the orchards. Fall plowing will have some effect by destroying many of the pupæ in the ground.

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[8] Maine Agr. Exp. Sta. Ann. Rept., 1889: 190.

PLANT LICE.[9]

Several species of plant lice attack the apple, but the most common in this State is the apple-tree aphis, *Aphis mali* Fab. This is the little, green louse that attacks the buds and leaves in the spring. It often occurs in great numbers on the under side of the leaves, sucking the sap from the tissues. This irritation causes the leaves to curl, thus affording partial protection to the insects. The winter is passed in the egg stage. Many generations and countless individuals, both winged and wingless, are produced during the summer. They secrete a clear liquid (honey dew) which sticks to the leaves and twigs and finally turns black, because of a black fungus which grows in it.

Treatment.— The trees should be carefully watched, and, when the lice first appear, sprayed thoroughly with a solution of whale oil soap and water — one pound to seven gallons. The lice may appear any time after the buds burst. It is important to give the infested trees at least one or, as is often necessary, two thorough applications before the leaves have become curled. It will be very difficult to reach the lice when they are protected by the curled leaves. The spray should be directed toward the under side of the leaves.

INSECTS ATTACKING TRUNK AND BRANCHES.

THE WOOLLY LOUSE OF THE APPLE.

(*Schizoneura lanigera* Hausm.)

This insect is easily detected by the white wool-like substance which the lice secrete and which clings to their bodies. They attack both the roots and young branches causing gall-like swellings. They are especially injurious to young trees and sometimes do serious injury to new grafts.

Treatment.— When occurring upon the roots considerable relief will usually result from the application of finely ground

[9] For a further discussion of plant lice, see Bulletin 139 of this Station, by V. H. Lowe.

tobacco dust about the infested roots. If the branches also are attacked, they should be trimmed off where practicable and burned. If considered more desirable, the lice may be killed by spraying with a solution of whale oil soap, one pound to five gallons of water, or kerosene emulsion, one part to five parts of water. When but few lice occur in small colonies on the trunk or large branches they may be easily and quickly killed by applying pure kerosene oil to the infested parts.

Some Australian horticulturists hold that injury from the woolly aphis can be avoided by selecting varieties the roots of which are proof against these insects. Wickson states[10] that "the Northern Spy is on the whole the best, but it has been shown that the roots of seedlings grown from Northern Spy seed vary somewhat in degree of resistance."

SCALE INSECTS.[11]

The scale insects include some of the most common and destructive insect pests of the orchard. Two species common in the apple orchards of the State are the oyster-shell bark louse, *Mytilaspis pomorum* Bouché, and the scurfy bark louse, *Chionaspis furfurus* Fitch. The San Jose scale, *Aspidiotus perniciosus* Comst., also attacks the apple. These insects are especially injurious to young orchard trees. The former two species pass the winter in the egg stage, the eggs having been deposited under the scales of the females. The eggs hatch in this climate in the spring, varying according to the season, from late in April or early May until June. The young lice soon settle down and insert their sharp threadlike mouth parts into the tender bark from which they suck the sap. The females form the oyster-shell-like scales, or, in the case of the other species, the thinner, more oval, whitish scales. The scales of the males of both species are more delicate, nearly white, and larger and more slender. The adult males are delicate two-winged insects.

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10 Univ. of Cal. Agr. Exp. Sta. Seed Bulletin, 1898–1899: 7.

11 For a further discussion of these insects, see Bulletin 136 of this Station.

Treatment for oyster-shell bark-louse.—Treatment may be made in the spring by spraying the trees as soon as the eggs hatch, either with whale oil soap, one pound to seven gallons of water, or kerosene emulsion, one part to seven parts of water. One or more applications should be made as required. For treatment of scurfy bark-louse, see page 450, and for San Jose scale page 449.

General Treatment Against Diseases and Insects which Attack the Apple.

When to spray.	What to use and what the treatment is for.
1. Just before leaf buds burst........	Paris green[12] against bud moth and case-bearers.
2. Just as leaf buds show green at the tips. About a week later than 1.	Bordeaux mixture[13] against scab, canker disease and leaf spot. Paris green[12] against bud moth, case-bearers, canker worms, tent caterpillar and various other leaf-eating insects.
3. Just before blossoms open. From seven to ten days later than 2.	Bordeaux mixture[13] against scab and leaf-spot. The most important single application. Apply thoroughly. Paris green[12] against canker worms, tent caterpillar and various other leaf-eating insects.
4. Just after blossoms fall..........	Bordeaux mixture[13] against scab and leaf-spot. A very important application; make it promptly and thoroughly. Paris green[12] against codling moth, canker worms, tent caterpillar and numerous other leaf-eating insects. The most important application against codling moth.
5. From ten to fourteen days after 4.	Bordeaux mixture[13] against scab and leaf-spot. If weather has been cool and wet, apply with especial thoroughness. Paris green[12] against codling moth.

[12] Paris green should be used at the rate of one pound to 150 gallons of water. If used alone, about two pounds of fresh slaked lime should be added to make it adhere and to prevent injury when applied to foliage. Green arsenite of copper, arsenite of lime, or other poison may be used instead of the Paris green, as directed in Bulletin 121. Paris green or the other arsenicals may be used with Bordeaux mixture. In that case, it is not necessary to add much extra lime.

[13] Use Bordeaux mixture 1-to-11 formula. Pure copper sulphate solution, 1 pound to 15 gallons or more, may be used when there is no foliage. It is cheaper, but does not adhere so well as does Bordeaux mixture. Directions for making and applying these mixtures are given in Bulletin 121. The Paris green or other arsenicals may be mixed with the Bordeaux mixture, and both may be thus combined in one application.

Generally, the scab may be controlled by three treatments if they are made promptly and very thoroughly. These three, as numbered above, are 3, 4 and 5. Winter treatment against the scab is not recommended. See page 404.

For treatment of lice or aphis, scale insects, rust, sooty blotch and fly speck consult the special discussion of these subjects on previous pages.

APRICOT DISEASES.

FRUIT ROT.

The ripe rot of apricot fruit is due to the same fungus as that causing ripe rot of cherries. It is discussed on page 420.

LEAF-SPOT.

(*Cylindrosporium padi* Karst.)

The fungus which causes apricot leaf-spot also causes a spotting of the fruit. When the leaves are attacked the diseased part usually drops out leaving a clean cut hole. In severe attacks the foliage is riddled with holes. The same fungus also attacks the foliage of plums and cherries. For the treatment, see plum leaf-spot, page 454.

GUMMING.

See discussion of the gumming of stone fruits, page 438.

APRICOT INSECTS.

CURCULIO.

This insect does great damage to apricots by causing wormy fruit. Frequently a large part of the crop becomes infested and drops unless measures are taken to kill the beetles before they deposit their eggs in the young fruit. This is best done by jarring as recommended in the discussion of this insect under the heading "Plum curculio." It is very important that the jarring begin *as soon as the fruit sets,* because the curculios do much injury to the very young apricots.

The other insects mentioned as attacking the peach are also liable to trouble the apricot.

BLACKBERRY AND DEWBERRY DISEASES.

ANTHRACNOSE.

Blackberry anthracnose is caused by the fungus which affects raspberries in a similar way. For description and treatment, see page 459.

LEAF-SPOT.

(*Septoria rubi Westd.*)

Description.— Blackberries, dewberries and raspberries are subject to a leaf-spot disease caused by *Septoria rubi.* The small, pale spots of dead leaf-tissue finally become dotted with black specks, the pycnidia of the fungus. In some seasons the foliage is quite seriously injured by this disease.

Treatment.— Goff[14] has tried treatment with Bordeaux mixture and other fungicides, but the results were not encouraging. No successful line of treatment is known.

RUST.

Blackberry rust is caused by the same fungus which causes the rust of raspberries. For description and treatment, see page 460.

BLACKBERRY AND DEWBERRY INSECTS.

The principal injurious insects of blackberry and dewberry are the cane borer and the saw fly. These also attack the raspberry. They are discussed on pages 461, 462.

CHERRY DISEASES.

BLACK KNOT.

It is claimed that the black knot of the cherry is caused by the same fungus as that which causes the black knot of the plum. If it is not the same fungus it certainly is so closely related that the

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[14] Goff, E. S. Journ. Myc., 7: 22.

same description of gross characters and the same lines of treatment will apply to both. For description and treatment, see "Plum black knot," page 452.

FRUIT ROT.

(*Monilia fructigena* P.)

Description.— The rotting of the ripening fruit on the tree often causes great injury to the crops of cherries, plums, apricots and peaches. A fungous parasite attacks the fruit and causes it to rot. The same fungus under favorable conditions, especially when the weather is warm and moist, and the growing shoots are tender and succulent, may attack the ends of the twigs and also the blossoms. Frequently the rotted fruit remains on the tree over winter in a mummied form and the following season, under favorable weather conditions, becomes covered with spores by means of which the disease is propagated. These mummied fruits, therefore, should be collected and destroyed before growth starts in spring, as a preventive of infection.

The fungus sometimes does considerable damage by destroying the blossoms, but usually it causes most loss by attacking the fruit. It occurs on unripe fruits, but usually spreads most rapidly and does most damage when the fruits are nearly or quite ripe, especially if they hang in clusters or touch each other. Under weather conditions very favorable to its growth it may practically ruin the ripening crop within a short time.

Treatment.— The disease may be prevented to some extent by treatment with fungicides, but it is extremely doubtful whether it can be entirely controlled by spraying. Bordeaux mixture applied soon after the fruit sets persists, to some extent, until the fruit ripens and will show on the ripe fruit. The other mixtures which have been tried are of doubtful utility, taking all things into consideration. For both this disease and the leaf-spot it is suggested[15]

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[15] Beach, S. A. N. Y. Agr. Exp. Sta. Bul. 117: 134.

that the trees be sprayed just before blossoming and again immediately after the blossoms fall, but no line of treatment is recommended.

Powell[16] recommends picking the fruit before it is fully ripe; that is, before it softens.

LEAF-SPOT.

(*Cylindrosporium padi* Karst.)

Description.— The leaf-spot of cherry, plum and apricot, which is caused by the fungus named above, at first appears as minute spots on the leaf, a sixteenth of an inch or less in diameter. On cherry and plum especially, the spots may have a reddish-tinged margin. Afterwards they increase in size and may enlarge to an eighth of an inch or more across. The spots soon become dark brown with a pale center, and in many cases the diseased tissue loosens and drops out leaving a clean-cut hole in the leaf. For this reason the disease is sometimes called the "shot-hole disease."[17] The disease may cause serious injury for sometimes the trees are nearly defoliated by it. Should this occur when the trees are heavily loaded with fruit, as it is especially apt to do with plums, the trees may be much weakened in vitality[18] and consequently more liable to winter injury.

Treatment.— It has been shown conclusively that the leaf blight may be controlled by proper treatment with Bordeaux mixture but in cherry orchards the treatments cannot be made at the most favorable time for controlling the disease because the spray mixtures adhere to the fruit and injure its market value.[19] From our present knowledge of the subject no line of treatment can be positively recommended for bearing cherry trees, but it is sug-

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16 Powell, G. Harold. Del. Agr. Exp. Sta. Rept. 1897: 193.

17 Duggar has shown that a shot-hole appearance in plum and peach foliage is not always due to fungous attacks, but may be caused by other injuries, notably by spraying with improperly prepared mixtures. See Proc. Soc. for Promotion Agr. Science, 1898, and Cornell Agr. Exp. Sta. Bul. 164: 385.

18 Beach. Annual Rept. this Station, 1896: 385; also Bulletin 98.

19 Beach. Annual Rept. this Station, 1896: 406.

gested that Bordeaux mixture (1-to-11 formula) be applied just before the blossoms open and again just after they fall as a partial preventive of leaf-spot and fruit rot.

GUMMING.

See discussion of gumming of stone fruits under gumming of the peach, page 438. To prevent gumming in the forks of cherry trees Wickson[20] advocates training the tree in such a way as to give wide, open forks where the branches join the trunk.

CHERRY INSECTS.

CURCULIO.

This insect injures cherries by causing the fruit to become wormy. It is the same insect as the plum curculio and is discussed more at length under the subject "Plum curculio," on page 454.

Treatment.— The curculio is commonly fought in cherry orchards by one or two applications of Paris green or its equivalent at the rate of one pound to three hundred gallons of water. Two or three pounds, at least, of unslaked lime should be added for every pound of the poison. Slake the lime and add to the mixture the same as in making Bordeaux mixture. The poison may be mixed with the Bordeaux mixture if desired as stated on page 417. Make the first application immediately after the blossoms have fallen and a second about ten days later.

FRUIT BARK BEETLE.

This is the same as the fruit bark beetle of peach discussed on page 442.

MAGGOT.

(*Rhagoletis cingulata?* Loew.)

This insect resembles the apple maggot in all of its stages. It attacks sour cherries and probably plums to some extent. It has

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[20] Wickson, E. J. California Fruits, p. 284.

recently proven a serious pest in some of the large cherry orchards of Western New York. A similar if not identical species occurs in some of the middle and eastern states.

The life history of this insect has not been fully worked out. It is known, however, that the eggs are laid nearly or quite under the skin of the ripe fruit, and that the maggots work in the flesh. In depositing the egg the female makes a small round hole, probably with her ovipositor, through the skin. Until the fruit has been sufficiently eaten to cause decay, this small hole is all there is to indicate that the maggot is inside. For this reason newly infested fruit is often quite difficult to detect. When full grown the maggots leave the fruit, as shown by specimens kept under observation by Lowe, and form the puparium or resting stage in any convenient place, such as the bottom of fruit baskets. If the fruit is on the ground the maggots will go into the ground for a short distance. The adults emerge in the spring early enough to lay their eggs in the earliest varieties of sour cherries. Egg laying probably continues throughout the season of the latest varieties. The number of broods is not positively known. The insect probably winters in the pupa stage.

Treatment.— This species will probably prove, like the apple maggot, a difficult one to control. Good cultivation and keeping the packing houses free from rubbish will undoubtedly have some effect. Lowe found in the infested orchards which he examined that the insect first attacked the fruit on a few trees in one section and gradually spread to other sections of the orchards. This indicates that it spreads slowly, and also that destroying the crop on the few trees that were first attacked, while an heroic measure, would probably be the means of preventing serious infestation of the orchard.

PLANT LICE.

Several species of plant lice attack the cherry. As a rule they do not occur on sour cherry trees in sufficient numbers to do serious injury. Sweet cherry trees, however, are quite frequently attacked by the black cherry aphis, *Myzus cerasi* Fab. The lice

are nearly black in color. Like other species of plant lice they multiply with great rapidity, soon covering the under sides of the leaves and causing them to curl and wilt. The lice prefer the young leaves at the tips of the branches, and will be found there in greatest numbers.

Treatment.— Where practical cut off and burn the ends of the twigs bearing the young and worst infested leaves. The trees should then be sprayed with whale oil soap solution or kerosene emulsion as recommended for the apple plant louse, page 415.

SLUG.

This insect also infests pear trees. It is discussed more fully under the heading "Pear slug" on page 451. The remedies to be used are there given.

CURRANT DISEASES.

LEAF SPOT.

(*Septoria ribis* Desm. and *Cercospora angulata* Wint.)

These two fungous diseases which cause spotting of currant leaves have been successfully treated with Bordeaux mixture by Pammel.[21] The spot diseases are usually seen to some extent each season, and in some cases their attacks are so severe as to nearly defoliate the bushes. Judging from the experiments thus far tried, the spraying should begin soon after the fruit sets, and continue at intervals of about two weeks until the fruit begins to color. One or two applications may be made after the fruit is harvested if thought necessary. One objection to the treatments before the fruit ripens is that the mixture is liable to remain on the fruit and injure its appearance when ripe.

Goff[22] has recently reported excellent results from a single thorough spraying with Bordeaux mixture made during the first week in July, after the fruit was harvested.

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[21] Pammel, L. H. Iowa Agr. Exp. Sta. Bul. 13: 45–46; Bul. 17: 419–421; Bul. 20: 716–718; Bul. 30: 289–291.

[22] Goff, E. S. Wis. Agr. Exp. Sta. Bul. 72: 30.

CANE BLIGHT.

Description.— This disease is characterized by wilting of the foliage and dying of the canes. Healthy and diseased canes commonly occur in the same hill. The disease may appear at any time during the growing season, but it is most virulent about the time the fruit is ripening. It appears that there are two forms of cane blight. The form occurring in the Hudson Valley[23] is caused by a sterile fungus which works in the pith and under the bark. In the western part of the State there occurs a currant cane blight which, according to Durand,[24] is caused by the semi-parasitic fungus, *Nectria cinnabarina* (Tode.) Fr.

Treatment.— Probably the most practical method of fighting cane blight is to go over the plantation at frequent intervals during the summer and cut out and burn the affected canes. In doing this, care must be taken to cut well below the lowest point of the disease. After cutting into diseased wood the pruning knife should be disinfected before it is used on healthy wood. A 5 per ct. solution of carbolic acid is a good disinfectant for this purpose.

Cuttings should be taken only from plants known to be healthy.

CURRANT INSECTS.

PLANT LICE.

The first indications that the plant lice are at work are the small bladder-like galls on the upper surfaces of the leaves. The galls soon turn red, increase in size and may finally include nearly the entire leaf. The lice congregate in large numbers in the corresponding pockets on the under sides of the leaves. Several species work on the currant, but the most common is the currant plant louse, *Myzus ribis* Linn.

Treatment.— The infested bushes should be sprayed with a solution of whale oil soap, one pound to seven gallons of water. The

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23 For an account of current cane blight in the Hudson Valley, see Bul. 167 of this Station, p. 291.

24 Durand, E. J. A Disease of Currant-Canes. Cornell Univ. Agr. Exp. Sta. Bul. 125.

first application is the most important, and should be made as soon as the lice appear. The spray should be directed so as to hit the under surfaces of the leaves. A second and third application about a week apart may be necessary.

SAW FLIES.

(*Nematus ventricosus* Klug.) (*Pristiphora grossulariae* Walsh.)

Description.— The first named species, which is popularly known as the imported currant worm, is much more troublesome than the latter, which is a native American species. The larvæ are the common " worms " that attack the leaves of both the currant and gooseberry, often quickly denuding the bush.

The adults are four-winged flies about the size of a house-fly. Their bodies are prominently marked with yellow. They appear during the first warm days of spring and deposit their eggs in single rows on the under sides of the midribs and larger veins.

The eggs hatch in about ten days. The newly hatched larvæ are light green in color. At first they eat small holes through the leaves, but as they grow larger, devour the entire leaf with the exception of the midrib and larger veins. Their color changes with successive molts until, when about full grown and before the last molt, they are a moderately dark green color, marked with numerous black dots. After the last molt they are plain green. When full grown, which is in about three weeks, they measure about three-fourths of an inch in length. The cocoons are formed either just above or a short distance below the surface of the ground, attached to the plant. The adults escape late in June or early in July. Eggs are soon deposited for a second brood, which passes to the chrysalis stage before winter sets in.

Treatment.— As soon as the " worms " appear spray the bushes with hellebore, one ounce to two gallons of water. Direct the spray toward the under sides of the leaves. It is important to make the first application while the " worms " are yet very young.

Otherwise it is more difficult to poison them. If a second application is necessary use an ounce of hellebore to one gallon of water.

GOOSEBERRY DISEASES.

LEAF-SPOT.

The fungi which cause the leaf-spot diseases of the currant also attack the gooseberry. They are discussed on page 424.

MILDEW.

(*Sphaerotheca mors-uvae* (Schw.) B. & C.)

Description.— The mildew usually makes its first appearance on the young shoots and leaves. Here it will first attract the observer's attention as a collection of some bright, frosty substance. On close examination it will be found to be composed of a mass of glistening white threads that spread rapidly under favorable conditions. The more mature portions of the fungus take on a dirty brown color. Later it attacks the fruit in a similar manner. The threads often spread over the berries until they are entirely covered with a mass of brown, felt-like mold, which renders them unsalable.

European varieties, when grown in this country, are particularly susceptible to the attacks of mildew. Many of those varieties produce very large, fine fruit and are so desirable both for home and market that they would be grown to a much greater extent than they now are, were it not for the attacks of this disease.

When setting out a plantation, a site should be chosen where the land is well underdrained and where there is an abundant circulation of air. Branches that droop close to the ground should be pruned back and the ground underneath kept free from grass or weeds, preferably by frequent shallow cultivation, otherwise by mulching.

Treatment.— Spraying should begin early in spring after the buds break and before the first leaves unfold, using one ounce of

potassium sulphide for two gallons of water. This treatment is repeated at intervals of from seven to ten days depending on the amount of rain that comes to wash off the applications. After the fruit is marketed spraying is no longer resorted to, although the mildew may continue through the season on the ends of growing shoots.

SUN SCALD.

The ripening fruit of the gooseberry is liable to sun scald. The skin at first has a bleached appearance and afterwards the fruit shrivels and drops. The conditions which bring about this trouble are not well understood. It sometimes causes serious loss.

Remedy.— The only remedy known at present is to pick the fruit while it is green, *i. e.,* unripe.

GOOSEBERRY INSECTS.

The saw flies which attack the gooseberry are of the same species at those which are found on the currant. See page 426.

GRAPE DISEASES.

The various prominent vineyard diseases of the State, with the exception of the anthracnose, may be controlled by spraying according to directions given for treating the black rot, page 430.

ANTHRACNOSE.

(*Sphaceloma ampelinum* DeBy.)

Description.— This disease attacks any tender portions of the growing vine. When the leaves are affected dark spots are first formed on their surface. As the disease advances these spots enlarge, and irregular cracks are often formed through the dead tissue. Frequently many of these small cracks run together, forming a long irregular slit through the leaf. Similar marks are formed on the tender shoots, though they are not so noticeable. When the fruit is attacked the disease is sometimes called bird's-eye rot. Circular spots are formed on the surface of the berry.

The spots may be of different colors and usually have a dark border; as the spots enlarge and eat in, a seed is often exposed in the center. The berries do not rot, but the tissue becomes hard and wrinkled. Sometimes the disease girdles the stem of a fruit-cluster, cutting off the supply of sap from the grapes beyond the diseased line and causing them to shrivel and die.

Treatment.— Anthracnose does not spread as rapidly as some other vineyard diseases, neither does it yield as readily to treatment. When a vineyard is badly infested with anthracnose, it requires prompt attention and careful treatment to control the disease. It is not satisfactorily controlled by the Bordeaux mixture treatment alone, which is recommended below for black rot and mildew. It is suggested that in addition to such treatment the plan be followed which is advocated by certain European authorities, of applying a warm saturated solution of copperas (iron sulphate) in spring when the buds are swelling, but before they begin to open. One per ct. or more of sulphuric acid may be added to the solution before it is applied. This solution must be handled with care as it is very caustic. It is applied with swabs or if the acid is not used it may be sprayed.[25] It is essential that the work be done thoroughly, covering all the surface of the canes.

Mr. T. H. King, Trumansburg, N. Y., reports that he has been successful in controlling this disease upon the Vergennes, which is very susceptible to the disease, by pulling the loose bark from the vines and spraying thoroughly with Bordeaux mixture in the spring before the buds start and again three or four weeks later.

BLACK ROT.

(*Laestadia bidwellii* (Ell.) V. & R.)

Description.— This disease may usually be found first on the leaves, where it forms circular, bright reddish brown, or pale brown spots on which there appear later little black dots or pim-

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25 Beach, N. Y. Agr. Exp. Sta. Bul. 86: 79. 1896. Lodeman, Spraying of Plants, pp. 45, 152, 294.

ples. Within the black pimples are developed the germs of the fungus which causes the disease. These germs are given forth and washed by rain, or blown by wind, to other leaves or fruit where they grow and form new diseased spots. In the fruit it also forms circular spots and develops black pimples like those formed on the leaves. The diseased fruit withers, turns black, and becomes hard and shriveled, clinging to the stems sometimes till the following spring. The disease may also attack the green shoots.

Treatment.— All diseased fruit shoud be taken from the vineyard, since it is capable of spreading the disease the following spring. Trimmings from the fruit containing diseased berries ought not to be returned to the vineyard in the shape of compost as is sometimes practiced, since the diseased berries are liable to spread the black rot through the vineyard.

This disease may be successfully controlled by thorough spraying if done at the right time. Bordeaux mixture, 1-to-11 formula, is used for this purpose. It is prepared as directed in Bulletin 121. The applications are made as follows:

I. Just as the pink tips of the first leaves appear.

II. From ten days to two weeks after the first spraying.

III. Just after the blossoming.

IV. From ten to fourteen days after the third treatment.

V. If a fifth treatment is necessary let it follow the fourth after an interval of from ten to fourteen days.

VI. If a later treatment than the fifth is needed, ammoniacal solution of copper carbonate should be used; as that it less liable to stain the fruit than the Bordeaux mixture. Directions for preparing it are given below.

The number of the treatments should be governed by the weather conditions and the severity of the disease. If the vineyard is not badly diseased, and if there is not an excessive amount of hot, wet weather, four treatments may be found sufficient for all practical purposes.

The early treatments are extremely important.

Thorough treatment is essential to success.

Paris green or other arsenicals which are recommended against the insects, may be combined with Bordeaux mixture, but not with the ammoniacal solution of copper carbonate.

Ammonical solution of copper carbonate.—The formula usually given for making this solution is as follows: Dissolve five ounces of copper carbonate in three pints of ammonia of 26° strength. When ready to apply, dilute with water so as to make fifty gallons. The undiluted solution may be preserved for some time in tightly closed vessels.

Penny finds[26] that the use of the strong undiluted ammonia in dissolving the copper is wasteful and unsafe. He recommends the following method of making the solution. "To one volume of 26° Beaumé ammonia (the strong ammonia of commerce) add from seven to eight volumes of water. Then add copper carbonate, best in successive quantities, until a large portion remains undissolved. The mixture should be vigorously agitated during the solution and finally allowed to subside, and the clear liquid poured off from the undissolved salt. A second portion should then be made by treating the residue of the former lot with more ammonia diluted as before, then with the addition of fresh copper carbonate, in every case with vigorous stirring or agitation. The method of making in successive lots will result in a richer solution of copper, at least unless an unwarranted length of time be taken." He finds that much less ammonia is required to dissolve a given amount of copper carbonate in this way than according to the method formerly followed of adding the strong, undiluted ammonia directly to the copper carbonate.

CHLOROSIS OR YELLOW LEAF.

The name is applied to a grape disease in which the foliage turns yellow, later becoming brown. It is common in some parts of the State.

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26 Del. Agr. Exp. Sta. Bul. 22.

Chlorosis is more likely to appear in wet seasons. Some varieties, as the Diamond, are much more susceptible than others. In some seasons portions of the leaves may become yellow, but eventually regain their normal color so that at the close of the season the vine appears to be in a healthy condition. In other instances the yellow color extends over the entire leaf; brown, dead patches appear; the leaf curls and eventually drops from the vine. If the vine loses its leaves two or three seasons in succession it is likely to die. One striking peculiarity of the disease is the fact that a badly diseased vine may appear by the side of a perfectly healthy vine of the same variety.

The cause of chlorosis, as given by foreign investigators, is the presence of a large amount of lime in the soil which prevents the roots from taking up an amount of iron sufficient for satisfactory growth. Their experiments show that the difficulty may be overcome by applying a small amount of sulphate of iron around affected plants. But since there are a number of good American varieties that are not subject to chlorosis, perhaps the better method to pursue is to plant only such varieties as are known to be free from this trouble.

The standard varieties given in the following list are, so far as we know, practically exempt from chlorosis:

Moore Early,	Concord,
Winchell,	Catawba,
Delaware,	Vergennes,
Worden,	Agawam.
Niagara,	

DOWNY MILDEW.

(*Plasmopara viticola* (B. & C.) Berl. & DeT.)

Description.— In some sections of the State the downy mildew causes considerable loss to the grape grower. It may attack nearly every portion of the current season's growth,— leaves, shoots and fruit. Its first appearance on the leaves, that will be

noticed by a casual observer, is in dry, brick red spots on the upper surface. On the under side of the leaf the diseased area will be covered with the interlaced threads of the fungus. The red spots increase in size until in many instances the entire leaf dies and falls to the ground. It frequently causes the berries to turn dull brown and become soft and shriveled. This appearance of it has been commonly called "brown rot." The spores are found on the threads which issue from the under side of the leaves or from the stems or fruit, the whole giving when fresh a glistening white downy appearance from which the disease takes its most common, and preferable name of "downy mildew." Later the parts of the fungus exposed on the surface assume a gray hue and so the disease has also been known as "gray rot." Some varieties, like Delaware, appear to be quite susceptible to the attacks of the disease and none of the cultivated varieties are known to be entirely exempt.

Treatment.— It may be successfully treated in the manner described for black rot. See page 430.

POWDERY MILDEW.

(*Uncinula spiralis* B. & C.)

Description.— Unlike many of our fungous diseases, the powdery mildew flourishes best during the dry weather of mid-summer. It usually begins its attack in June, though it may appear earlier. Its name is descriptive of its appearance, as it forms dull white, powdery patches on the young shoots on the upper surface of the leaves. When the fungus is abundant it seriously checks the growth of the vines by absorbing the nourishment that should have gone to their development. The berries may be attacked at any stage of growth and they are injured or destroyed in the same way as are the shoots or leaves.

Treatment.— It may be successfully treated in the manner described for black rot. See page 430.

GRAPE INSECTS.

CANE BORER.

(*Amphicerus bicaudatus* Say.)

A small cylindrical beetle, which works as a borer in its mature stage. It injures the grape by burrowing into the stems in spring near the base of the new growth. It breeds in the dying wood. The larva sometimes feeds upon the grape vines.

Treatment.— As it breeds in the dying wood, careful cutting away and destroying of such wood will help to check the insect.

GRAPE-VINE FLEA-BEETLE.

(*Haltica chalybea* Ill.)

Description.— The adult insects are shining steel-blue flea-beetles measuring about one-fifth of an inch in length. They live during the winter under the bark of the old vines or in rubbish in the fields. They emerge from their winter quarters during the first warm days of spring, and feed upon the opening buds and young leaves. Egg laying begins late in April or early in May. The eggs are placed singly near the buds or upon the leaves and hatch in about ten days. The young larvæ are dark brown in color but soon become prominently marked with black dots and patches. They are full grown in from three to four weeks at which time they measure about a quarter of an inch in length. They feed on the leaves, devouring only the soft parts at first, but finally eating irregular holes through the leaves. When ready to pupate they go a short distance into the ground. The adults emerge from these pupæ during the latter part of June or early in July. They probably feed during all of the summer, finally seeking shelter for the winter as above indicated.

Treatment.— The vines should be sprayed with Paris green, one pound to fifty gallons of lime and water, just before the buds begin to swell. Much pains should be taken to make this appli-

cation thorough. Later, when the worms appear on the leaves, Paris green may be applied at the usual strength, one pound to 150 gallons of lime and water, or combined with Bordeaux mixture. Both upper and under surfaces of the leaves should be covered.

GRAPE FRUIT WORM.

(*Eudemis botrana* Schiff.)

Description.— The young caterpillars feed within the grapes finally causing them to turn dark colored and to wither. This injury is sometimes mistaken for the black rot. After devouring the soft parts of one grape the caterpillar goes to another, fastening the two together by a silken thread. This may be continued until several in a bunch have been destroyed by one caterpillar. The young caterpillars are very light green in color with a brown head. When full grown they measure about one-fourth of an inch in length and are dark olive green in color tinged slightly with red. The cocoon is formed on a leaf and is partially composed of two small pieces cut out of the leaf. The adults emerge in about ten days. The fore wings have a bluish tinge and are marked with brown, while the posterior wings are dull brown. The moths are small, measuring nearly half an inch from tip to tip when the wings are spread. The eggs are probably laid late in June or early in July. There is probably but one brood annually in this State.

Treatment.—As the caterpillars spend most of their lives within the grape berries, spraying will have little or no effect. There seems to be no better way than picking and destroying the infested fruit and the leaves containing the cocoons.

GRAPE LEAF HOPPER.

(*Typhlocyba vitifex* Fitch.)

There are several species of leaf hoppers which attack the grape, but this species is probably the most common in this State. These

little leaf hoppers are often erroneously called thrips. They jump quickly when disturbed.

Description.— The adult insects measure about one-eighth of an inch in length. They vary greatly in color, but the prevailing color is usually light yellowish green. The back and wings are ornamented with bright red, yellow and brown. They are found upon the vines from spring until fall. They feed together, sucking the sap from the leaves, principally from the under surface, causing them to turn brown in patches. Writers disagree as to the egg-laying habits of this species. The young resemble the adults in form, but are not provided with wings and are green or yellowish green in color. There are several broods during the season. Some of the adults of the last brood hibernate in any convenient rubbish about the vineyard.

Treatment.— The vineyards should be kept free from rubbish. Much good may be done by thoroughly spraying the vines with kerosene emulsion, one part to from seven to ten parts of water, or whale oil soap, one pound to seven gallons of water. This is not entirely satisfactory as many of the leaf hoppers will fly before the insecticide reaches them, but some benefit is derived from the emulsion or soap solution that remains on the leaves as it undoubtedly makes them offensive to the insects.

A practical method of combating this insect is found in what is popularly known as the shield method. The shield consists of a frame with a cloth stretched over it and saturated with kerosene oil, with tar softened until it is very sticky or with some other sticky substance. When ready for use it is carried in a horizontal position between the rows. The vines are agitated at the same time and as the insects fly or jump into the air many of them will come in contact with the sticky surface where they soon die or are wet with kerosene which is fatal to them. This method should be used during the warm part of the day and should be continued every day until the insects are materially lessened in numbers.

GRAPE-VINE SAW FLY.

(*Blennocampa pygmaea.*)

Description.— The larva of this saw fly is a yellowish green slug, with numerous rows of black dots across the body. They feed together principally upon the under sides of the leaves. The life history of this species is similar to that of the currant saw-fly. See page 426. There are two annual broods.

Treatment.— The infested vines should be sprayed with hellebore, one ounce to two gallons of water. If the spraying is not done until the larvæ are half grown or over, use one pound of hellebore to one gallon of water. Much pains should be taken to wet the under surfaces of the leaves. Paris green, one pound to 150 gallons of lime and water, may be used before the grapes are half grown.

PEACH DISEASES.

Caution.— Before discussing the diseases and insect enemies of the peach, attention should be called to the fact that the foliage of stone fruits and especially of the peach is *peculiarly liable to injury* from Paris green, London purple or copper in solution. For this reason the former should not be used stronger than one pound to about three hundred gallons of water and at least two or three times as much freshly slaked lime as poison should be used. It is doubtful whether more than two sprayings with Paris green or London purple should be given even if diluted to the strength just stated. If Bordeaux mixture is used especial care should be taken to have an excess of lime in the mixture.

CROWN GALL OR ROOT KNOT.

Description, etc.— In this disease large knots appear on the roots. The knots are irregular in form, rough on the surface, sofe and spongy within and of various sizes, from the size of a pea to the size of a fist. They may occur on any part of the root system, but are found most commonly at the point where the roots branch off from the trunk; hence the name crown gall.

Occasionally, they occur also on the trunk above ground. In all cases the knots are detrimental to the trees and when they occur at the crown the tree is worthless.

The disease is common in some of the nurseries in the State. The cause of it is wholly unknown. There are indications that it is infectious but this has not been proven.

Similar knots occur on the roots of the raspberry, blackberry, pear, apple, plum, apricot, grape, and a few other woody plants. Among fruit growers it is the popular opinion that the disease is the same on all of these different plants, and that any one of them may communicate the disease to the others. However, this has not yet been demonstrated by carefully conducted experiments.

Treatment.— No remedy is known. Affected trees should never be planted. It is not even safe to plant trees from which the knots have been removed. Avoid planting fruit trees in soil known to be badly infested by the disease.

FRUIT ROT OR RIPE ROT.

(*Monilia fructigena* P.)

The ripe rot of the peach is caused by the same fungus as that which produces the ripe rot of cherry and plum. It is discussed on age 420.

Treatment.— Chester[27] who has given special attention to this subject advocates spraying with Bordeaux mixture just before the blossoms open and again after the fruit sets. Spray with copper acetate (finely powdered, 8 ounces to the barrel), when the fruit is ripening. Copper acetate does not discolor the fruit as Bordeaux mixture does. Observe the caution given above concerning the liability of injuring peach foliage by spraying.

GUMMING.

The formation of gum by the apricot, cherry, peach or plum may follow any injury by cuts or bruises or by the attacks of

27 Chester, F. D. Ninth Ann. Rept. Del. Agr. Exp. Sta., 1897: 28.

insects or fungi. The young bark of stone fruit trees may be nearly covered with gum pockets as a result of bruises from hail stones. Wounds made in pruning are often followed by a flow of gum. It has been shown by some experiments that where the peach is pruned during the period of greatest vegetative activity, *i. e.*, from April to August, there is a greater production of gum in the wounds than where the pruning is done later[28].

When gumming results from adverse conditions of environment, of from over bearing, excessive pruning or any other cause which severely checks growth, it may often be remedied by making the conditions as favorable for growth as possible, as, for example, by frequent tillage, by the use of stable manure or other fertilizers, by draining the soil, by thinning the fruit to prevent overproduction and by treatment against diseases and injurious insects.[29]

LEAF CURL.

(*Exoascus deformans* (Berk.) Fckl.)

Description.— The name is descriptive of the disease. The disease is caused by a fungus which not only attacks the leaves but may be found in the twigs as well. The curled leaves become distorted, crumpled, enlarged and curled. The disease may often be detected when the leaves first start from the buds in spring. The diseased leaves eventually fall so that in early summer the tree may be almost defoliated. In 1898 the disease caused a loss of many thousands of dollars to the fruit growers of the State by injury to the trees and by the premature dropping of the fruit which followed the loss of the foliage.

Treatment.— It appears to be demonstrated that leaf curl may be largely prevented by spraying with Bordeaux mixture,[30] 1-to-11

28 Zeit. f. Pflanzenkrankheiten, 6 (1896): 58, 59.

29 For a more complete discussion of this subject, see Beach, S. A. "Gumming of Stone Fruits." Amer. Gard., 19 (1898): 606.

30 Some advise the use of copper sulphate solution, 1-to-15 or 1-to-20 formula, instead of the Bordeaux mixture, but we advocate the latter because it adheres so well.

formula, in spring before the buds begin to open. Some advise later sprayings but as the peach foliage is very susceptible to injury from the use of spraying mixtures including even Bordeaux mixture, we are not prepared at present to outline a satisfactory line of treatment for the foliage.

LITTLE-PEACH DISEASE.

This disease appears to have been first described by Taft[31] in March, 1898. In October of the same year Smith[32] published a more extensive account of it. It seems to have been known to some extent among peach growers for many years.[33] It is considered to be as contagious and as fatal as the yellows.[34] Dr. Smith describes it as a disease in which the peach fruit is from one-half to one-third the diameter of healthy fruit, and it may ripen from one to two weeks later than the healthy fruit. The leaves average, perhaps, one-half normal size and have a sickly color. The larger roots appear to be all right but the ultimate rootlets appear to be diseased. No fungous parasite has as yet been found to be the cause of the trouble. The remedy now advocated is the same as for yellows, viz.: Dig out and burn the diseased trees.

YELLOWS.

The best treatment for peach yellows is to dig out and burn the diseased trees. It has not been found that a healthy tree planted where a diseased tree stood is more apt to have the yellows than if planted elsewhere, other conditions being similar. Among the characteristics of the disease may be mentioned the appearance of clusters of willowy shoots, sickly color of the foliage, premature ripening of the fruit and red colored spots in the flesh of the fruit.

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31 Taft, L. R. Mich. Agr. Exp. Sta. Bul. 155: 303–304.

32 Smith, E. F. Notes on the Michigan disease known as "Little Peach." Fennville (Mich.) Herald. Oct. 15, 1898.

33 Mann, W. T. Proc. W. N. Y. Hort. Soc., 1899: 142.

34 Robinson, F., and Morrill, R. Proc. W. N. Y. Hort. Soc., 1899: 142.

PEACH INSECTS.

BORER.

(*Sannina exitiosa* Say.)

Description.—The adult insects are beautiful moths. The male measures about an inch and the female an inch and a half from tip to tip of the expanded wings. The general color is deep steel blue. The female has a broad band of orange across the abdomen. They appear during May and early June. The eggs are usually deposited on the bark at or near the surface of the ground, although they are sometimes deposited higher up on the trunk and even upon the larger limbs. The eggs are only a few days in hatching and the young larvæ quickly work their way into the sap wood where they feed during the remainder of the season. They remain dormant during the winter in their burrows, form a cocoon and finally issue as moths as above indicated. There is but one brood annually.

Treatment.— As preventive treatment numerous washes have been suggested. In a series of expriements which included a large number of trunk washes Slingerland[35] reports the best success with gas tar. The tar was warmed slightly to facilitate handling and applied to the trunk. It " apparently kept out four-fifths of all the borers, only a small percentage of the trees became infested and no injury resulted to the trees." Professor Slingerland also states that in his experience " the tar did not interfere with the growth of the trees in the least." This treatment should be combined with the digging out method. He also states that in this State the applications of washes, such as gas tar, should be made between June 15 and July 1, and " should remain in perfect working order until October 1." It should be remarked that gas tar is a substance of very variable composition and instances are known where disastrous results to the trees followed its use in the manner which is here described.

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35 Cornell Univ. Agr. Exp. Sta. Bul. 186, pp. 217, 224–225.

Keeping wood ashes about the base of the trees is considered by some extensive growers to be an effective treatment. The surest treatment is to kill the borers every spring and fall with a flexible wire inserted in their burrows or to remove them with a knife.

After the borers are dug out in the spring in May, mound six inches high or more with fine earth, packing it tightly against the base of the tree. This compels the moths to lay their eggs on the bark above the top of the mound. About the first of August carefully examine the trunk by removing a little earth at the top of the mound where the borers, if any, may be easily found. Remove them with the knife. A second search should be made in October and a third one during the following May. If the earth is left at its usual level without mounding, the eggs are deposited so near the roots that the borers can easily work downward to where it will be difficult to find them.

BUD MOTH.

(*Tmetocera ocellana* Schif.)

Sometimes very destructive to the peach. The caterpillars bore into the buds and even into the wood beneath. Treatment same as recommended on page 409.

CURCULIO.

The plum curculio is sometimes a serious pest in the peach orchard. Remedies for this insect are discussed under "Plum curculio" on page 455.

FRUIT-BARK BEETLE.

(*Scolytus rugulosus* Ratz.)

Description.— The adult insects are black, somewhat cylindrical beetles about one-tenth of an inch long and about one-third as broad. They appear early in the spring and bore small round holes through the bark to the sap wood. The eggs are laid beneath the bark and the grubs feed on the sap wood, mak-

ing characteristic galleries. Pupation takes place under the bark, the adults finally gnawing their way out. There are probably several broods in one season. It attacks a variety of fruit trees.

Treatment.— As a preventive measure trees should be kept in a healthy, vigorous condition; as such trees are less liable to attack than weak ones. Trees which become badly infested should be dug up and burned.

PEAR DISEASES.

FIRE BLIGHT.

(*Bacillus amylovorus* (Burr.) De Toni.)

Description, etc.— This disease shows itself in the dying of entire twigs, large branches or even the tree itself. It is a bacterial disease that has long been known but whose real nature was first discovered in 1879 by Dr. Burrill of Illinois. It was afterwards studied very carefully at this Station by Dr. Arthur[36] and more recently by Mr. M. B. Waite [37] of the United States Department of Agriculture.

The disease usually makes its first appearance soon after the blooming period. The young fruit clusters and the twigs bearing them turn black. The leaves also blacken and die but do not fall. If affected twigs are not removed the disease rapidly works its way down into the larger branches.

According to Waite[38] the blight germs do not live over winter in the soil. Moreover, he finds that in the majority of the affected branches even, the germs die soon after the close of the growing season. It is only in a small proportion of the affected branches that the germs survive the winter. Such "hold over" cases, as he calls them, become centers of infection during the following spring. Branches in which the germ is alive do not show a definite line of demarcation between the healthy and diseased

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36 See Annual Reports of this Station, 1884: 357; 1885: 241; 1886: 275.

37 Waite, M. B. The Cause and Prevention of Pear Blight. Year-Book U. S. Dept. Agr., 1895: 295–300.

38 Loc. cit.

wood. The infection is spread chiefly by insects, especially by bees.

Pear blight attacks several other pomaceous plants — the apple, crab apple, quince, etc.

Treatment.—Although the cause of the disease is now well known no thoroughly successful method of treating it has been found. The only thing that can be done is to cut out and burn the diseased parts as soon as the blight appears. This should be done promptly; for the disease spreads rapidly. Waite recommends[39] that all trees subject to the disease be thoroughly inspected several times during the growing season. He says that the two most important periods for such inspection are: (1) About two weeks after blooming; (2) just before the leaves drop.

The cutting should be done several inches below the lowest point of discoloration, in order to make sure that all of the disease is removed. Care should be taken never to cut into healthy wood with a knife or saw that has come in contact with diseased wood, until after the tool has been disinfected by wiping it off with a cloth saturated with kerosene, a five per ct. solution of carbolic acid, or some other germicide.

LEAF BLIGHT.

(*Entomosporium maculatum* Lev.)

Description.—This is caused by a parasitic fungus which makes its appearance early in the spring. It is first found on the new leaves where it appears as bright, reddish spots on the upper surface. These spots rapidly increase in size and later the leaves turn brown and finally fall. It attacks the young twigs in the same manner and frequently kills back many of them. When the fruit is attacked the bright colored spots are first formed. These spots soon become dark colored, and spread out in every direction; the surface of the pear becomes rough where attacked by

[39] Fifty-Seventh Ann. Rept. N. Y. State Agr. Soc., 1897: 787.

the disease and at these places the growth is checked. Sometimes the fruit becomes cracked as it does when attacked by the scab. This disease appears to be more severe in states south of New York and in regions near the Atlantic coast than it is in the interior of the State, where it causes little damage except as a nursery disease.

Treatment.— The treatment advocated for pear scab is also recommended for this disease when it appears in the orchard.

LEAF SPOT.

(*Septoria piricola* Desm.)

Description.— This disease may be readily distinguished from the one last described if the two are carefully compared. The leaf spot when fully developed has a somewhat angular outline and whitish center in which appear small black specks, the bodies in which the spores of the fungus are borne.

Treatment.— The only experiments in treating this disease which have come to our notice are those by Duggar[40] who advocates similar treatment to that recommended against leaf-blight.

SCAB.

(*Venturia pirina* Aderh.[41])

Description.— This disease is caused by a fungus very similar, both in appearance and in the injury which it does to leaves and fruit, to the apple scab fungus. It robs the leaves of the nourishment which they are preparing for themselves and for the growth of the tree and fruit; it spots the fruit and in very severe attacks causes it to become one sided, distorted or cracked. While it does not kill the trees or branches as the blight may do, still it is believed that no disease, year after year, causes so great loss in pear orchards in New York State as does the scab. Some varieties appear to be comparatively exempt from its attacks while

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40 Duggar, B. M. Cornell Univ., Agr. Exp. Sta. Bul. 145: 602–604.

41 This is the ascosporic stage of *Fusicladium pirinum* (Lib.), Fckl.

others suffer quite severely. With varieties which are thus injured by its attacks, it weakens the tree, it lessens the yield, it makes a large part of the fruit unsalable or of an inferior grade, and even the No. 1 fruit sells for less in the market than it would were it free from the blemishes caused by the scab. It is also conceded that fruit free from scab keeps better and is handled easier than the fruit of the same variety blemished with scab spots.

Treatment.— This disease may be controlled by treatment with Bordeaux mixture.[42] Paris green or its equivalent may be used at the same time against the codling moth and leaf eating insects. The general treatment recommended for the scab and other pear diseases is given on page 452.

PEAR INSECTS.

BARK LICE.

See under " Oyster-shell Bark-louse " and " Scurfy Bark-louse."

BLISTER MITE.

(*Phytoptus pyri* Scheuten.)

Description.—The first indications of the presence of this insect in the spring are the small reddish spots on the upper surfaces of the young leaves. These spots indicate where the adult mites that have been hibernating on the twigs burrowed into the leaves to deposit their eggs. These spots finally turn black. The eggs soon hatch and the young mites burrow into the leaf, feeding upon its soft tissues. Toward fall the adults migrate to the twigs to remain all winter. There are probably several broods annually.

Treatment.—The infested trees should be sprayed in the spring a short time before the buds burst, either with kerosene emulsion diluted with seven parts of water or with a solution of whale-oil soap, one pound to seven gallons of water. One thorough application has been found to be sufficient. Pruning closely in winter and burning the twigs will also aid in checking the insect.

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42 Beach, S. A. Bulletin 84 of this Station.

BORER.

See "Sinuate Pear Borer."

BUD MOTH.

The eye-spotted bud moth which attacks pears, is the same as that which infests apple trees. It is also known as the bud worm. Treatment for it is given under apples. See page 409.

CASE BEARERS.

PISTOL-CASE-BEARER. CIGAR-CASE-BEARER.

These insects also infest apple trees and have been discussed under apples. See page 409.

CODLING MOTH.

This insect which causes so much loss to apple growers by causing wormy apples, also attacks pears. It may be treated as recommended on page 412.

LEAF BLISTER MITE.

See " Blister Mite."

PEAR MIDGE.

(*Diplosis pyrivora* Riley.)

Description.—The first indication of injury by this insect is the stunted and dwarfed fruits. If one of these fruits is cut open the maggots will be found near the core. The adult insect is a small two-winged fly somewhat resembling a diminutive mosquito. According to Prof. J. B. Smith[43] it appears early in the season before the buds of the pear blossoms open. The eggs are probably laid in the blossoms and hatch within a few days. The young maggots bore into the embryo fruit, where they remain feeding near the core until full grown. When ready to pupate they leave the fruit and go into the ground to a depth of from one-half an inch to two inches. After remaining unchanged for a time they make

[43] N. J. Agr. Exp. Sta. Bul. 99, page 5.

"oval cocoons of silk covered with grains of sand" (Smith.) This probably takes place any time from early spring to mid-summer, depending upon the locality, although in this State most of them go into the ground in June. They remain as pupæ in the ground all winter, emerging as adults in the spring. Lawrence pears are especially liable to attack.

Treatment.— This insect has proved a very difficult one to control. Experiments have been made with a view to destroying the pupæ in the ground, but it has been found that in order to successfully check the insect a dangerous amount of the insecticides tested must be applied to the soil. Hand picking, where practical, is probably the most satisfactory method of checking the insect. It should be done in June.

OYSTER-SHELL BARK-LOUSE.

This insect also has been discussed under apples, page 417. It is sometimes very injurious to young pear trees.

PEAR PSYLLA.

(*Psylla pyricola* Forst.)

Description.— This insect causes injury in two ways. First, by sucking the sap; second, by disfiguring trees and fruit. Its presence is usually betrayed by the honey dew secreted by the young, wingless forms. The honey dew afterwards becomes covered with a black mold giving the leaves and twigs a black unsightly appearance.

The adult is an active four-winged insect measuring about one-tenth of an inch in length. It has been compared to a miniature seventeen year locust. A number of broods are produced during the summer, and the adults which live through the winter are distinct in form from the summer adults. They appear early in the spring and deposit their eggs in protected places on the bark. The eggs hatch within a few days and the little larvæ, or nymphs, at once commence to suck the juices from the young leaves and

twigs. Where the nymphs are numerous they take so much nourishment from the trees that the new growth is seriously checked. The whole tree assumes a stunted, unhealthy appearance. As a natural result the fruit crop is greatly lessened and, in some instances, trees have been killed. The first brood in the spring probably does the most direct injury. A favorite place for the young nymphs is in the axils of the leaves and at the base of the fruit stems. Within two or three days after hatching they cover themselves with honey dew which finally becomes so abundant as to disfigure the leaves and fruits, the amount of injury done in this way varying of course with the number of nymphs.

Treatment.— The young nymphs are most easily reached. Close watch for them should be kept when the leaves are unfolding in the spring. As soon as the nymphs are found spray the trees thoroughly with kerosene emulsion diluted with about ten parts of water[44] or with a solution of whale-oil soap, one pound to from five to seven gallons of water. Two applications about ten days apart will probably be necessary. It is important to begin the work before the nymphs have covered themselves with honey dew as it is then much more difficult to reach them with a spray.

SAN JOSE SCALE.

(*Aspidiotus perniciosus* Comst.)

Description.[45]— This insect may be briefly described as a small, nearly circular, ash-gray scale with a prominent dark nipple at the center. These are the female scales. They are always greatly in excess of the males and are chiefly responsible for the injury which is done. The San Jose scale attacks the bark, leaves and fruit. In common with certain other scale insects it causes a

44 Some growers use a much stronger emulsion than this with apparently no injury to the trees.

45 This insect is discussed more in detail in Bulletin 136 of this Station, pages 587–593, by V. H. Lowe.

crimson discoloration of the sapwood and fruit. It multiplies with great rapidity. In examining a tree for this insect the trunk and larger limbs and the fruit should receive an especially close scrutiny as the scales are often found here in large numbers when only scattering on the smaller limbs.

Treatment.—The treatment of this insect is a matter of so great importance that it will be made the subject of a separate bulletin. Where it has once become firmly established it probably cannot be exterminated. When recently introduced it has in some cases been exterminated by burning the infested trees, or by thorough treatment with whale-oil soap at the rate of two pounds to a gallon of water, or by both. The most effective known method of treatment is fumigation with hydrocyanic acid gas. The use of kerosene and water or crude petroleum is still in the experimental stage and cannot as yet be recommended for general use.

SCURFY BARK-LOUSE.

(*Chionapsis furfurus* Fitch.)

Description.— This insect sometimes occurs in large numbers upon young pear trees. The scales are a dirty white color, broadly wedge shape in outline and vary in length from about one-sixteenth to nearly one-eighth of an inch.

The life history of this species is very similar to that of the oyster-shell bark-louse; with both species the eggs are retained under the parent scale during the winter. The eggs vary greatly in number, from ten or twelve upwards, as many as seventy-five having been found under a single female scale. They hatch from the first to the middle of May. There is probably but one brood annually. The male scale is much smaller than the female, is elongate, with nearly parallel sides and is a clearer white color. The adult male is a delicate two winged insect.

Treatment.— The treatment for this insect is the same as for the oyster-shell bark-louse. See page 417.

SINUATE PEAR BORER.

(*Agrilus sinuatus* Oliv.)

Description.— This insect was recently introduced into this country from Europe. It has become seriously injurious in some parts of the eastern United States. It makes long zig-zag galleries between the bark and wood, finally girdling and killing the tree. It is said to live two years in the larval stage. The larva is slender, and has the first segment back of the head much enlarged. The adult is a small, slender beetle. The eggs are laid on the bark of the tree.

Treatment.—When a tree becomes infested it is very difficult to get the borers out, and it is usually impractical to attempt to do so. As preventive measures some good may be done by placing mechanical obstructions on the trunks, such as tarred paper wound about the trunk, or wire netting; the object being to prevent the adult from depositing eggs in the bark. Whitewashing the trunk with ordinary whitewash to which enough Paris green has been added to tinge it slightly, or with a strong soap wash, one pound of whale oil soap to one gallon of water, has been recommended. The trunks should be kept covered with one of these washes during May and June.

PEAR SLUG.

(*Selandria cerasi* Peck.)

Description.— The adult insect is a small, dark-colored, four-winged fly. The slugs make their appearance in the latter part of May or early June. At first light in color they soon become darker and are covered with an abundance of slime. The slugs feed on the upper surface, skeletonizing the leaves, and where very abundant they cause serious injury. Leaves that are badly injured wither and fall.

Treatment.— If upon examination it is found that the insects are likely to appear in sufficient numbers to cause much damage, no time should be lost in spraying the trees with Paris green. If the trees are being treated for fungous diseases the Paris green

should be combined with the Bordeaux mixture. A second brood of this insect usually appears in August. The only thing to be done is to spray when the indications are that the slugs are numerous enough to be injurious. On low trees they are sometimes treated with air-slaked lime or road dust, by throwing the dust or lime over the trees.

GENERAL TREATMENT AGAINST DISEASES AND INSECTS WHICH ATTACK THE PEAR.

When to spray.	What to use and what the treatment is for
1. Just before blossoms open.	Bordeaux mixture[46] against the scab, leaf blight, leaf spot and canker disease.
2. Just after blossoms fall.	Bordeaux mixture[46] against the scab, leaf blight, leaf spot, etc.
	Paris green[47] against codling moth and leaf-eating insects generally.
3. From ten to fourteen days after 2.	Bordeaux mixture[46] against the scab, leaf spot, leaf blight, etc.
	Paris green[47] against codling moth and leaf-eating insects generally.

For treatment of fire blight, bud moth, case bearers, etc., consult the special notice of these subjects on previous pages.

PLUM DISEASES.

BLACK KNOT.

(*Plowrightia morbosa* (Schw.) Sacc.)

Description.— This disease causes swellings underneath the bark, finally rupturing it and developing a spongy texture covered

46 Use Bordeaux mixture, 1-to-11 formula. Directions for making and applying are given in Bulletin 121. The Paris green or other arsenicals may be mixed with the Bordeaux mixture if desirable to apply both at one time.

47 Use Paris green at the rate of 1 pound to 150 gallons of water, with about two pounds of fresh slaked lime added to make it adhere, and to prevent injury to foliage. Green arsenite of copper, arsenite of lime, or other poisons may be used instead of Paris green, as directed in Bulletin 121. These arsenicals may be mixed with Bordeaux mixture instead of water, at the same rate as given above. In that case, not much extra lime need be added.

with dark olive-green mold. In this stage the summer spores are produced which spread the infection to other trees.

Late in the season the knot becomes hard with a black surface, which finally becomes covered with fine black pimples inside of which are matured the winter spores. The winter spores escape late in winter or early in spring and serve to spread the disease. A more extended discussion of this disease is given in Bulletin 40 of this Station, and in the Annual Report for 1893, page 686.

Treatment.— The best known remedy for this trouble is to cut out and burn the knots. They can be found most readily after the leaves have dropped in the fall. They should then all be removed before mid-winter so as to be sure of destroying them before the spores mature and escape. Early in the summer the new knots should be watched for and promptly removed and destroyed. The infection frequently comes from the knots on neglected plum or cherry trees along fence rows or in neighboring orchards. In removing the knots the branch should be cut off three or four inches or more below where the knot appears, so as to remove the threads of the fungus that may extend down the branch to a considerable distance from the knot. The same disease also affects various wild plums and wild and cultivated cherries. It is rarely found on sweet cherries but sometimes is very destructive to the Morello class.

FRUIT ROT.

(*Monilia fructigena* P.)

The ripe rot or fruit rot of the plum is caused by the same fungus as that which causes the rot of the cherry fruit.

Treatment.— The treatment advocated for the leaf-spot will hold this disease in check somewhat. The spraying of the ripe fruit presents the same difficulties as it does with the cherry. See page 420.

When there is reason to fear that the disease will attack the blossoms, treatment with Bordeaux mixture should be made just before the blossoms open. Thinning the fruit is no doubt a par-

tial preventive, because when the rot attacks one of a cluster of fruits it usually spreads till every fruit in the cluster is diseased. When the fruits do not touch each other the disease is less destructive.

LEAF SPOT.

(*Cylindrosporium padi* Karst.)

This disease is discussed under leaf spot of the cherry. See page 421. In general it is more liable to produce the shot hole appearance on plum foliage than on cherry foliage.

Treatment.—As a result of extended experiments it can be stated that the plum leaf spot may be controlled by thorough treatment with Bordeaux mixture, 1-to-11 formula. In some seasons two treatments are most economical, but under conditions favorable to the disease at least three should be given.[48] If but two treatments be made give the first about ten days after the blossoms fall, but not later than June 1; make the second treatment about three weeks later. The disease may be better controlled by three treatments and usually three treatments will be most profitable. Make the third from three to four weeks after the second.

YELLOWS.

The Japanese plums are subject to a disease which has the appearance of peach yellows. It occurs on trees which have been worked on plum roots as well as on those which are on peach roots. No remedy is known.

The treatment recommended is the same as that which is recommended for peach yellows — dig out and burn the diseased trees.

PLUM INSECTS.

PLUM CURCULIO.

(*Conotrachelus nenuphar* Herbst.)

Description.— The adult is a small, peculiar, gray beetle. It passes the winter under the bark of trees, or under rubbish, and

[48] Beach, S. A. Sixteenth Ann. Rept. this Station, 1897: 211.

comes forth early in the spring to deposit its eggs in the young fruits, commencing as soon as they are formed. It does this by puncturing the tissue and inserting the egg. After the egg is deposited, the beetle cuts a crescent-shaped groove around one side of the puncture evidently to prevent the growing tissue from crushing the egg. The eggs hatch in a few days when the little worm, or larva, at once commences to feed on the fruit causing much of the infested fruit to fall while still young and that which remains on the trees ripen prematurely and soon decay.

The curculio does not confine its attacks to plums, but it usually infests plum orchards and if left unmolested, often destroys an entire crop.

Treatment.— It has been found that the beetles' manner of protection is to fall to the ground when disturbed. Here they curl up so as to resemble bits of bark. Advantage is taken of this habit in fighting the insect by a process known as jarring. The trees are jarred by three or four strokes with a padded crutch or mallet and the insects are caught on sheets spread underneath the tree and destroyed.

The curculio catcher commonly used in the vicinity of Geneva is one made by Mr. J. B. Johnson, Geneva, N. Y. The frame over which the sheet is stretched is attached to a two-wheeled cart. The sheet slopes downwards to the center where an opening allows the bugs to be swept into a tin box underneath the sheet and between the wheels. A slit at one side allows the cart to be run directly under the tree and two or three jars bring down the bugs which are swept into the box above mentioned, by means of a short handled broom. The cultivated ground is made smooth by rolling to prepare it so that the cart wheels will pass over it readily. Jarring should be begun as soon as the fruit sets and be continued as long as the curculio are found in sufficient numbers to pay for jarring, which is usually for about three weeks. Early morning is the best time to do this work. Towards the middle of the day, especially on bright days, they are more active and apt to fly.

The beetle feeds on the plum leaves and for this reason spraying the trees with Paris green or London purple has been advocated. No doubt the insects may be killed to some extent in this way but the foliage of stone fruit trees is particularly liable to injury from Paris green or London purple so that these poisons must be used sparingly and much diluted. When the insect is abundant the jaring is undoubtedly the best way of controlling the pest.

GREEN FRUIT-WORMS.

The green fruit worms sometimes are so abundant on the plum as to cause much damage. The treatment recommended is given on page 413.

PLANT LICE.

Several species of plant lice attack the plum. They collect in great numbers on the under sides of the leaves, causing them to curl and finally drop off. The infested trees should be sprayed with whale-oil soap, one pound to seven gallons of water, as soon as the lice appear. The spraying should be directed from the under side so as to reach all of the lice.

QUINCE DISEASES

CANKER OF TREE. BLACK ROT OF FRUIT.

The canker of the tree and black rot of the fruit of the quince are caused by the fungus which causes similar trouble with the apple and pear. For a discussion of the disease and remedial measures see page 399.

BLIGHT. (FIRE BLIGHT.)

This disease is caused by the same parasite which produces the fire blight of the pear. It is discussed on page 443.

LEAF BLIGHT AND FRUIT SPOT.

(*Entomosporium maculatum* Lev.)

Description.— Fruit spot and leaf blight of the quince are caused by the same fungus that causes pear leaf blight. When a

fruit is attacked, numerous small black specks appear on its surface. As the spots increase in size they often grow into each other and form a large, dark, diseased area. The disease does not extend so deep into the tissue of the fruit as to make it entirely worthless, but the market value is greatly lessened. When the fruit is attacked before it has reached its full size, it often occurs that the quinces, like the diseased pears, are mishapen and undersized. Greater damage is done to the trees when the leaves are severely attacked. The loss of foliage in midsummer not only leaves the fruit undeveloped but it is a severe check to the growth and vigor of the tree.

Treatment.— Favorable results in treating this disease with the Bordeaux mixture are reported. It is suggested that the treatment recommended for apple scab be used against quince fruit spot and leaf blight, making the first spraying when the blossom buds have appeared, the second just as the blossoms are falling, and a third about two weeks later.

RUST.

(*Gymnosporangium* spp.)

Description.— The rust is due to a fungus which becomes established and develops within the tissues of the quince branches or fruit. It causes knotty branches and peculiarly distorted fruit on which there appear tiny fringed pits filed with orange colored dust giving the diseased parts quite a brilliant appearance.

In a different form this rust fungus attacks the red cedar and the common juniper, forming galls on their branches. In these galls are developed spores which, distributed by the winds to quinces, juneberries, hawthorns and apples, become established on these trees and cause the rust. Usually the rust is not abundant enough on quinces to cause serious injury. It is usually recommended that the cedar and juniper trees in the vicinity be destroyed to prevent the breeding of the fungus on them and that the rusted fruit or branches also be removed and destroyed. The

former recommendation is not always practical, and whether the latter course will do any good has not been definitely determined.

QUINCE INSECTS.

BORER.

These are the same as those described under apple insects, page 406. The trunks of the trees should be examined carefully in spring and fall and the borers dug out. Various other remedies have been advocated, but apparently none of them take the place of systematically removing the grubs.

CODLING MOTH.

(*Carpocapsa pomonella* Linn.)

This insect is the same as that which causes wormy apples and pears as described on page 412. It should be treated by spraying with Paris green or some other arsenical poison as soon as the fruit sets, followed by one or two later applications at intervals of ten days, or even less if heavy rains fall in the meantime. The poison thus used is also recommended for the curculio mentioned below. It may be combined with Bordeaux mixture when that is used against fruit spot and leaf blight, using one pound for one hundred and fifty gallons.

CURCULIO.

(*Conotrachelus crataegi* Walsh.)

Description.— The adult insect is somewhat larger than the plum curculio. It is broader just back of the thorax and is a brownish gray color mottled with white. Its life history as worked out by Slingerland[49] is substantially as follows: The winter is passed in the grub stage in an earthen cell two or three inches below the surface of the ground. Here the transformation to the pupa takes place in the spring. The time when the adults

[49] Cornell Univ. Agr. Exp. Sta. Bul. 148.

emerge varies with the weather conditions. They may appear any time from late in May until late in July. The adults feed on the young quince fruits and possibly on the leaves. The eggs are laid in "little pits" made by the female beetles in the fruit. The eggs hatch in a few days and the grubs feed in the fleshy part of the fruit until full grown when they go into the ground to pass the winter. There is but one brood annually.

Treatment.— As with the plum curculio, jarring is considered the most satisfactory method of combating this insect. The trees are jarred in the same manner as plum trees for the plum curculio. The "curculio catcher" is mounted on low wheels so that it can be used under the quince trees. As the time when the curculios appear varies, probably with the season, no definite time for beginning the work of jarring can be given. The trees should be watched after the last week of May. The presence of the curculios will be easily ascertained by a few trials at jarring. If they are found the jarring should be continued as long as they are numerous.

RASPBERRY DISEASES.

ANTHRACNOSE.

(*Gloeosporium venetum* Speg.)

Description.— This disease ordinarily makes its first appearance on the young canes when they are less than a foot high. Its presence may be detected by the appearance of small dark or purple colored spots, which rapidly increase in size and change from the dark color to the brown or dirty white in the center as the fungus feeds outward in all directions leaving the dead tissues behind. The slightly raised outlines of the spots vary in color from dark brown to bright purple. In severe attacks the spots are so numerous that they soon coalesce and form continuous blotches that may nearly or completely girdle the cane. The effect on the cane is practically the same as if so much bark had been removed with a knife. While anthracnose is preëminently

a disease of the canes it may occur on any part of the plant above ground. It is most destructive to black raspberries, but also attacks purple raspberries and blackberries and perhaps still other species of *Rubus*. Red raspberries appear to be exempt.

Treatment.[50]— Since, in most instances, a raspberry plantation reaches its limit of profitable production when three or four years old it seems that a rotation of crops, combined with sanitary measures, is the surest method of preventing loss from this disease. As the disease lives over winter in the canes, the old canes, together with the badly diseased new ones, should be removed as soon as the fruiting season is over.

Experiments have shown that the disease may be checked by spraying with Bordeaux mixture, beginning when the new canes are about six inches high and keeping them well protected with the mixture until the fruit is two-thirds grown. Ordinarily, however, spraying for anthracnose is not likely to pay.

RUST.

(*Puccinia peckiana* Howe. Syn. *Caeoma nitens* Schw.)

Description, etc.— This disease is often called the orange rust on account of the orange color of the spores which are produced in dense masses on the underside of the rusted leaves. Sometimes the spore masses occur also on the canes. The fungus attacks blackberries, dewberries and raspberries. It is quite common on wild plants and where these are growing in the vicinity of cultivated varieties the diseased plants among them should be destroyed to prevent them from becoming a source of infection.

Treatment.— Clinton[51] states that the fungus enters the very young underground shoots and growing up through the canes finally appears in the leaves. Since the fungus grows within the canes and infection appears to take place at the root, the only

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50 Paddock, W. The Anthracnose of Black Raspberry. N. Y. Agr. Exp. Sta. Bul. 124.

51 Clinton, G. P. Orange Rust of Raspberry and Blackberry. Ill. Agr. Exp. Sta. Bul. 29.

preventive treatment which can be recommended is digging out and burning the infested plants immediately upon the first appearance of the disease. This treatment will materially check the disease. Affected plants may usually be detected before the rust breaks out on the leaves. The diseased leaves have a pale orange tinge and present a sickly appearance which one soon comes to recognize as characteristic of rust-infested plants. Diseased canes are also apt to be much freer from prickles than are healthy canes.

LEAF-SPOT.

(*Septoria rubi* Westd.)

A leaf-spot of raspberries is caused by the same *Septoria* which attacks blackberries. It is discussed on page 419.

The disease seems to be less troublesome on raspberries than it is on blackberries.

ROOT KNOT.

The roots of raspberries are often covered with galls which are similar to those found on peach roots (see page 437) and are probably due to the same cause. Our knowledge of these root galls is imperfect. To both raspberry and the peach they are very injurious. There is some reason for believing that the disease may be communicated from the peach to the raspberry and *vice versa*. Hence it is advisable to avoid planting peaches on soil in which raspberries have knotted badly. Neither should raspberries be planted where peaches have been affected with the root knot.

RASPBERRY INSECTS.

CANE MAGGOT.

(*Phorbia* sp.)

Description.— This insect works only in the new shoots causing them to wilt and finally die. This wilting of the shoots is first noticeable in May. The adults first appear in spring toward the

latter part of April. The eggs are laid near the tips of the new growth. They hatch within a few days. The little white maggots which emerge from them burrow into the pith of the shoot. According to Slingerland[52] they burrow downward in the pith until they have reached about half the length of the canes when they work nearly out to the bark and each makes a tunnel around the shoot, thus girdling it from the inside. They continue feeding on the pith at the point where the girdling was done, almost severing the shoots. After doing this injury the maggots proceed to murrow downward in the pith, finally reaching the base of the shoots where they transform to the pupa stage. This point in their development is probably reached some time in June. They remain in this condition until the following April.

Treatment.— As the insects work inside the shoots they cannot be reached with a spray. Undoubtedly the most practical method of treatment consists in cutting off the wilted shoots several inches below the wilted portion.

SAW FLY.

(*Monophadnoides rubi* Harr.)

Description.— The adult insects are about the size of a housefly. They appear in the spring and are most abundant in May. The eggs are laid from the under side of the leaf within the leaf tissue. They are usually placed along the midrib and larger veins. The tissue above the eggs turns a light brown in color, causing the infested leaves to become spotted. The eggs hatch in about a week. The young larvæ are light green in color and are well covered with spine-bearing tubercles. They feed at first on the softer tissues, but finally the entire leaf with the exception of the midrib and larger veins is devoured. They also have been known to feed on the tender bark of the new growth and to do some injury to the flowers and fruit. Toward the latter part of June they go into the ground near the bushes upon which they have been feed-

[52] Cornell Univ. Agr. Exp. Sta. Bul. 126, p. 58.

ing, to a depth of two or three inches, where the cocoons are spun in which the transformation to the pupa stage slowly takes place. The transformation is not completed until the following spring. There is but one brood annually.

Treatment.— If the leaves become spotted as above indicated, they should be examined, and if indications of the eggs or larvæ are found they should be sprayed with hellebore, one ounce to the gallon of water, as soon as the young larvæ are numerous. Both the upper and under surfaces of the leaves should be covered. Where only a few bushes are infested the insect may be easily checked by brushing the larvæ onto the ground about the bushes. If the ground is soft and loose most of the larvæ will be unable to return.

STRAWBERRY DISEASES.

LEAF-SPOT.

(*Sphaerella fragariae* (Tul.) Sacc.)

This disease is also called strawberry " rust " or " leaf-blight." It frequently causes much damage by injuring the foliage so that the plants are incapable of perfecting a full crop of fruit, even though a full crop has set, or as Thaxter states, it also attacks the fruit stems and hulls, " cutting off the supply of nourishment from the berries and disfiguring them by the withering of the calyx."

When the spots first appear on the leaves they are of a deep purple color, but later they enlarge and the center becomes gray or nearly white. Portions of the infested leaves frequently assume bright red tints, and when badly diseased finally wither and die.

Treatment.— Bordeaux mixture, 1-to-11 formula, used as advocated by Hunn in the Annual Report of this Station for 1892, p. 682, gives beneficial results. When setting a new plantation be particular to remove the diseased leaves before taking the plants to the field, or if the plants must be trimmed in the field, the diseased leaves should not be left where they can communicate the disease to the new foliage as it grows out. The following treatment is then suggested:

Spray the newly set plants soon after growth begins and follow with three or four treatments during the season, as seems necessary. The following spring, spray just before blossoming and again in from ten days to two weeks. As soon as the fruit is gathered it is generally a good plan to mow off the foliage if badly diseased and burn it if the beds are to be fruited a second season. Should drought follow, the plants may not recover from this treatment sufficiently to give a satisfactory crop the following year.

Varieties differ greatly in their susceptibility to leaf spot. Consequently, one of the best ways to avoid loss from this disease is to plant those varieties which are least subject to it.

STRAWBERRY INSECTS.

CROWN BORER.

(*Tyloderma fragariae* Riley.)

Description.— The adult insect is a dark brown beetle, of the curculio group, measuring about one-sixteenth of an inch in length. The beetles appear in June or July. The eggs are laid on the plant above ground not far from the crown of the root. The eggs hatch into small, white, legless grubs. These grubs burrow down into the crown where they feed until full grown. Pupation takes place within the excavation, the beetles finally escaping about the middle of August. They are unable to fly. There is but one brood annually.

Treatment.— The crown borer is most injurious on old beds, and as each plant that becomes infected is eventually doomed, it will usually be most practical to dig up and burn the infested vines.

GRUBS.

The larvæ or grubs of the common May beetle and other closely related species, frequently do much injury by feeding on the roots of strawberry plants.

The beetles lay their eggs in sod ground. The eggs hatch into white grubs, which feed on the roots of various plants until the

third year, when they pupate, finally coming from the ground as beetles.

Since the grubs live in the ground until the third year after the eggs were laid, it is good practice not to use land for strawberries before the third or fourth year after it was in sod.

SAW FLY.

(*Emphytus maculatus* Nort.)

This insect is only occasionally injurious in this State. The adult insect is a four-winged fly of the general habits of the currant and raspberry saw flies. The larvæ feed upon the leaves. There are probably two broods annually, the second brood passing the winter in the ground.

The larvæ may be killed by spraying the infested plants with hellebore, one ounce to the gallon of water.

METEOROLOGICAL RECORD

FOR

1899.

PRECIPITATION BY MONTHS SINCE 1882.

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September	October.	November.	December.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1882	.....	.....	.....	.....	.....	3.69	2.42	2.37	1.25	0.62	1.22	0.55	.....
1883	0.48	1.44	0.88	1.58	4.45	4.12	2.98	3.47	2.12	2.10	1.54	0.73	25.89
1884	1.83	2.01	2.54	0.83	2.49	2.01	2.33	1.44	3.17	1.67	1.01	0.97	22.30
1885	1.07	0.61	0.12	1.26	1.58	2.49	4.64	5.02	2.11	2.88	1.36	0.76	23.90
1886	1.13	0.95	1.13	4.13	1.92	2.92	4.41	2.86	2.31	1.39	3.48	1.24	27.87
1887	0.18	2.17	0.48	1.37	0.46	2.01	6.37	3.03	0.75	1.74	1.58	1.35	22.29
1888	0.78	1.04	1.43	3.09	2.79	3.88	0.99+	4.02	2.73	3.47	2.02	1.24+	27.48
1889	2.99+	0.25	0.66+	3.28	1.21	7.47	4.57	1.98	2.50	3.32	3.44	1.62	32.28
1890	2.16	1.45	2.16	2.20	5.49	5.26	1.07	4.34	5.81	4.54	2.40		36.83
1891	1.44	1.57	3.25	1.63	0.49	4.31	3.52	3.16	0.47	3.65	0.74	3.29	27.52
1892	0.57	0.88	0.55	0.67	4.04	3.95	1.89	4.77	1.12	1.34	2.67	0.72	23.17
1893	1.62	3.71	1.94	2.59	4.92	3.08	3.68	5.38	2.68	1.59	1.09	1.56	33.84
1894	2.21	2.71	1.36	2.43	7.03	1.77	1.50	1.22	4.64	3.59	0.43	0.47	29.36
1895	0.96	0.00	0.29	1.33	2.88	.....	.....	2.66	0.94	0.72	2.31	2.49	.....
1896	1.19	2.28	0.84	0.41	2.31	3.71	4.12	3.33	4.27	2.26	2.18	0.71	27.61
1897	0.64	0.21	2.12	1.90	2.19	3.16	5.23	1.27	2.36	0.73	2.53	1.39	23.78
1898	1.74	0.33	1.54	2.03	1.90	2.39	1.32	3.60	1.86	3.83	2.03	0.33	22.90
1899	0.37	0.30	1.22	1.12	1.69	1.71	4.15	1.05	2.23	2.69	1.36	1.46	19.35

WIND RECORD FOR 1899.

DATE.	January.				February.				March.				April.			
	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.
1	3	....	....	21	....	....	....	18	1	....	....	18	....	....	....	24
2	....	....	13	2	....	1	2	2	1	7	....	....	....	....	....	18
3	....	....	23	1	....	1	....	1	....	5	9	....	....	....	....	24
4	....	....	24	....	6	....	....	15	....	10	14	....	6	....	....	14
5	....	....	....	24	....	....	....	9	....	6	6	12	6	....	....	12
6	4	8	....	3	2	....	....	10	....	6	....	12	1	4	3	3
7	....	....	....	24	....	....	....	....	14	2	....	4	....	10	11	....
8	....	....	8	8	....	....	....	15	....	....	....	22	....	....	....	19
9	7	1	....	4	....	....	....	24	....	4	3	6	....	....	....	22
10	....	....	....	6	....	....	....	24	....	13	....	3	3	....	....	15
11	....	....	....	....	....	....	....	21	....	....	24	....	1	6	11	....
12	....	6	12	....	....	....	....	4	....	....	14	10	....	2	10	12
13	....	....	24	....	5	....	....	14	2	....	....	18	3	5	1	14
14	....	....	16	8	....	....	....	18	1	12	....	2	....	....	11	9
15	....	....	....	16	....	....	20	....	....	4	17	3	....	....	....	15
16	....	....	11	....	....	....	14	....	....	....	....	24	....	....	....	14
17	....	....	....	19	....	....	2	....	2	9	....	3	....	....	....	14
18	15	....	....	1	....	....	....	8	....	6	15	1	....	2	11	....
19	....	....	....	4	....	....	....	17	....	....	....	15	....	....	12	3
20	....	....	16	....	....	....	2	22	....	....	....	24	5	....	....	4
21	....	....	15	8	....	....	5	1	....	9	6	6	8	....	....	3
22	....	....	....	24	....	....	4	16	....	4	20	....	....	....	13	....
23	....	3	12	1	7	....	....	17	....	....	6	18	8	....	....	7
24	3	....	8	9	8	....	....	11	....	....	....	24	....	5	....	....
25	....	....	....	19	3	7	....	7	....	12	3	1	5	1	3	1
26	....	....	19	5	....	4	20	....	5	2	....	10	6	....	....	5
27	....	....	....	19	....	....	3	21	....	1	2	....	1	8	6	....
28	....	....	12	2	....	....	14	5	....	1	17	....	....	....	24	....
29	....	....	....	15	....	....	....	....	....	....	....	24	....	....	24	....
30	....	....	....	18	....	....	....	....	....	....	....	12	....	....	18	4
31	....	....	....	15	....	....	....	....	5	....	....	9	....	....	....	....
Total hours of movement	32	18	213	276	31	13	86	300	31	113	156	231	53	43	158	256
Per cent of time in each direction	5.9	3.3	39.5	51.3	7.2	3.0	20.0	69.8	5.3	19.5	26.8	48.4	10.4	8.4	31.0	50.2

WIND RECORD — (*Continued*).

DATE.	May.				June.				July.				August.			
	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.
1	1		15	4				12				18	1	4	1	3
2	6		7	11				15	2			11	1	1	11	3
3	19			4	2		1	10	1	3	3	4	6			11
4	3	5	3	4		7	2	2		2	6	1	5			5
5	2	3	9	6	1			13			15	2	8			11
6		2	1	4			4	14				13	9			15
7	7			9				14	3		3	3	15			5
8	6		2	4				22			3	7				24
9	11			8			1	17	2			15	1	12	2	2
10		6	5	3	8			12				18	1	14	1	
11	1	4	6	13		7	10			1	3	6	1	2	1	
12	2			7			22		4		4	6		3	21	
13			11	12		2	9	7	3			8			1	20
14				23				11	1			13	7	3		1
15				19				9			5	2		10		
16	3	9	3	2				15				11	1	6	4	
17	6	7	2	2	5			12	2			16	1	7	1	
18			12	9		1	2	8				24		7	7	
19				24	4			5	3			15	4	2	2	5
20	2			22	4			11					8			
21				19	3			17	1			9		1	4	5
22	9	4		7		10	3		5							21
23	6	2		2			10	9								13
24	1	5	3		5			7			13		1	2		12
25		3	7		5		4	6			22		6		2	4
26			5	1	10			5			2	10	1	8		2
27			2	13	1			18				13		11	7	
28	10			1	*				5	1		3		10		
29		8	11	1	2			14	2		4	11		6	12	
30				21	9			9				22			14	3
31			4	8					7			13			7	2
Total hours of movement	95	58	108	263	59	27	68	294	41	7	83	274	77	109	98	167
Per cent of time in each direction	18.2	11.1	20.3	50.4	13.2	6.0	15.2	65.6	10.1	1.7	20.5	67.7	17.1	24.2	21.7	37.0

WIND RECORD — (*Concluded*).

DATE.	SEPTEMBER.				OCTOBER.				NOVEMBER.				DECEMBER.			
	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.
1	....	2	8	6	7	....	....	23	17	1	....	....	....	....	7	7
2	3	2	....	14	....	....	....	10	17	1	....	....	....	....	....	18
3	1	....	8	14	2	5	2	....	....	18	....	....	....	....	....	8
4	15	....	....	1	8	....	10	5	....	....	2	19	6	....	....	18
5	....	....	11	7	5	....	....	12	....	....	2	22	....	....	9	12
6	12	....	....	....	5	....	....	....	....	....	....	24	....	....	4	16
7	....	1	14	....	....	....	....	....	....	....	....	10	....	....	15	3
8	....	....	2	18	....	14	2	....	....	....	8	2	2	....	....	22
9	7	....	....	13	....	7	9	....	....	....	7	11	....	7	6	....
10	....	....	14	3	....	....	9	....	2	....	....	21	....	9	12	....
11	....	2	19	....	....	....	9	1	7	2	....	6	....	8	16	....
12	....	....	6	16	....	....	....	....	....	....	....	24	....	....	7	13
13	....	....	....	23	....	....	....	....	....	....	....	14	....	....	4	14
14	....	....	....	23	2	2	8	5	....	11	4	....	1	11	....	8
15	1	....	....	15	9	....	....	5	....	6	7	10	....	3	2	19
16	....	10	6	....	....	2	12	....	13	....	....	9	....	....	....	12
17	....	....	24	....	....	7	16	1	....	12	4	....	....	2	22	....
18	....	....	21	....	6	....	....	11	....	1	15	....	....	....	15	1
19	8	....	....	2	3	....	....	21	....	....	....	15	....	....	9	15
20	....	....	....	18	4	....	....	19	3	....	....	21	....	....	....	14
21	....	....	....	22	4	....	....	12	....	....	....	7	0	0	0	0
22	....	....	....	22	....	....	18	....	1	....	....	12	....	....	2	....
23	4	7	1	7	....	....	15	....	6	....	....	....	....	2	13	....
24	....	....	12	....	....	....	8	4	....	....	....	5	....	3	8	11
25	4	....	15	5	....	....	6	4	....	....	....	24	....	....	....	21
26	....	....	....	24	2	....	9	8	....	....	1	17	....	....	....	23
27	....	....	1	21	10	....	....	1	....	....	....	14	....	....	4	5
28	....	....	16	....	....	3	11	....	....	....	11	....	....	....	....	7
29	....	....	7	12	....	....	2	18	....	....	1	8	4	....	....	20
30	....	....	....	24	6	....	....	14	1	....	2	2	....	....	....	24
31	....	....	....	....	4	5	....	1	....	....	....	....	....	....	12	7
Total hours of movement	55	24	185	310	77	45	146	175	67	52	64	297	13	45	167	318
Per cent of time in each direction	9.6	4.2	32.2	54.0	17.4	10.2	32.9	39.5	14.0	10.8	13.3	61.9	2.4	8.3	30.7	58.6

SUMMARY OF DIRECTION OF WIND FOR 1899.

	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Total.
January	32	18	213	276	539
February	31	13	86	300	430
March	31	113	156	281	581
April	53	43	158	256	510
May	95	58	108	263	524
June	59	27	68	294	448
July	41	7	83	274	405
August	77	109	98	167	451
September	55	24	185	310	574
October	77	45	146	175	443
November	67	52	64	297	480
December	13	45	167	318	543
Total hours of movement	631	554	1,532	3,211	5,928
Per cent of time in each direction	10.7	9.3	25.8	54.2	....

READINGS OF THE STANDARD AIR THERMOMETER.

DATE.	January.			February.			March.			April.			May.			June.		
	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m	6 p. m.	7 a. m.	12 m	6 p. m.	7 a. m.	12 m.	6 p. m.
1	3	3.5	7	1.5	10	11	20	31	29	28	32	29	64.5	72	68	71.5	82	78
2	9	14.5	23.5	10	26	21	27.5	34	34	26	26	27	60	80.5	70.5	60.5	71	67
3	23	34	34	22	24	25	32	41	41	28	35	33	50.5	55	55	62	73	66
4	41	44.5	47	18.5	23	23	37	40	38	28	39	36	41	64	56.5	63	73	85
5	35.5	36	26.5	19	27	21	43	53.5	32	29	38	36	43.5	67	57	70	89	83
6	22	24	32.5	16	21	19	25	36	44	29	42	46	50.5	68.5	70	78	86.5	78
7	16	21	15.5	11.5	20	15	28	29	29	40	45	38	53	69.5	64	72	83	77
8	6	21	35	14	15	6	18.5	27	27	33	38	38	50	62	62	72	79.5	75
9	19	16	10	—5	—1	—3	24	30	33	31	35	26	50.5	58.5	61	64.5	73	69
10	—2.5	3	1.5	—6	0	—4	28.5	37	37.5	30.5	43	41	47	70	68.5	56	75	68
11	—2	5	2	—7	3.5	0	43	49	45	32	51.5	53	58.5	59.5	68	58.5	73	75
12	10	23.5	29.5	—4.5	3	4	49	59	39	44.5	51	56	53	68	72	69.5	82	80
13	29	35	35	1	4	4	29.5	27	25	42.5	53	53	57	61.5	53	70	84.5	86
14	35	41.5	39	5	13	14	24.5	27	29	53.5	67	55	43	53	54	75.5	87	85
15	36	38	39.5	15	29	29	34	35	36	43	50	49	41	55.5	53.5	78	71	75
16	36	43	42	21	36	34	28	29	24	37	36	42	48	49	49	55	57	59
17	35	36	33	32	41.5	38.5	14	21	25	37.5	52	52	47	57.5	56	59	72.5	73
18	16.5	16	13	35	43	40	32	40	34	44.5	69	55	57	54	56	63	76.5	79.5
19	9	26	26	34	31	40	28	27	24	51.5	66	59	47	49	49.5	69	79	78.5
20	19	34	35	40	47	45	16	24	17	50	59.5	62	47	47.5	51	75	83.5	71
21	31	39	35	39	47	41	18	23	29.5	44	55	57	46	51	54	58	66.5	67.5
22	33	31	30	44	43	37	31.5	40	41.5	44	64	64	49.5	59	56	63	72.5	75
23	21	33	39	31	29	27	36	33	30	49	64	60	47.5	62.5	64	75	92	87
24	40	34	29	17	25	23	25	27	26	47	65	65	54	72.5	70.5	72	84	74
25	23	23	24	17	29	28.5	23	30	33	54.5	66	62.5	59	75	73	66	78	78
26	29	46	43	32	35	39	24	27	28	57	66	60.5	56.5	66	75	64	76	74
27	10	8.5	5	34.5	35	29	31.5	32.5	33	55	60	70	61	69	68	67	80	81.5
28	3	17	22	22	38	47.5	35	36	39	53	68	69.5	54	61	64	66	71	66
29	7	9	7.5	.....	.....	.....	26	28	26	60	77.5	77	64.5	75.5	76	58.5	71	73
30	6	11	13	....	....	.....	23	30	32	66	74.5	78.5	67	73.5	68	60.5	75	74.5
31	—0.5	15	9	.....	....	....	27.5	33.5	33	....	.....	.....	64	79	73	....	.....	...
Average	19.3	25.3	25.3	18.2	24.9	23.4	28.5	23.4	31.7	42.3	52.9	52.0	52.6	63.6	62.5	66.4	77.2	75.3

READINGS OF THE STANDARD AIR THERMOMETER — (*Concluded*).

DATE.	July.			August.			September.			October.			November.			December.		
	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.
1	65	84	87	66	82.5	75	70	72.5	70	37	42	43	45	45	46	46.0	52	40
2	72	90	91	72	84	75	65	68	65	35.5	42	41	30.5	35	32	40	45	45
3	73	91	92	70	84	80	69	83	78	32	47	47	32	40	43.5	36	38	33
4	78	91	78	73.5	86	83	56	65	63	44	65	58	36	45	42	31	31	28
5	74	84	75	70	77	73	59	80	80.5	50.5	63.5	57	41	44	39	20	24	25.5
6	70	69	67	65.5	79	76	62.5	67.5	63.5	48.5	61	54	37	42	40	26	26.5	20
7	67	77.5	78	65	73.5	72	54.5	74	78	38	58	51	36	52	48	14	26	28
8	66	73	68.5	68.5	73	72	70	68	64	42	57	56	37	52	49	37	40	39
9	60	61	72	61	76	75	56	66	62.5	52	56	58	35	52	50	20	26	23
10	68	79.5	80.5	64	74	79	49	70	69	45	66	65	46	47	41	33	36	40
11	63	82	73	66	82	84	60.5	59	64	53.5	65	65	36	36.5	35	43	39	51
12	68	80	80	74	85.5	74	62	72.5	62	52	68	68.5	28	30	29	54	55	48
13	61	72	70	65	76	72	51	54	56.5	54	73	72	30	33.5	30.5	37	45	35
14	67	79	81	63	71	63.5	45	56.5	52.5	58.5	78	72	30	36	34	28	26	27
15	66	80	79	56	75	74	43.5	60	61	59	64	63	37	43	40	22	25	21
16	73	79.5	79.5	65	79	79	50	73	73	54	77	65	41	38	35	22	27	24
17	69.5	79	73	64.5	86	84	64	80	79	59	71	65.5	33	45	45	28	35	35
18	64	75.5	75	68	87	86.5	62	78	78	54.5	59	59	46	56	54	32	40	39
19	61	67	67	70	90	83	64	66	59	51.5	61	53	48	52	47	47.5	37	33
20	60	73.5	78	73	92.5	83	59	58	57	42	47.5	42	38	38	38	21.0	40	37
21	76.5	87.5	82	75	94	72	53	61	58	34	40	37	31	46	43	30	41.5	37
22	63	74	71	70.5	76	75	57	65	57	30.5	47	50	46	47	44	29	44	37
23	66	76	79.5	62.5	66.5	69	48	59.5	57	47	56	60	34	38	37	32	40	42
24	67	80	81	65	74	78.5	60.5	65.0	68.5	57	76	73	37	37	36	40	36	34
25	69	79	80	69	85	80	67	73	60	50	69	70	34	36	36	19	22	15
26	70	84	85	68	82	77.5	49	47	42	60	72	69	34	38	38	12	16	14
27	80	81	78	66	67	63	44	57	54	52	54	47.5	39	43	42	15	20	19
28	66	79	79	63	78	78	47	65	62	49	60	61	41	39	36	15	24	19
29	66	83	84	67	80	80	52	45	44	50	47	49	43	45	41	13	18	13
30	65	74	74	70.5	83	80	39	50	42	45	54	51	44	48	48	0	7	3
31	62	75	76	68.5	85	82	.....	.....	.....	39	47	43	.....	.....	.....	3	11	11
Average	67.6	78.7	77.9	67.3	80.1	7.72	56.3	65.4	62.7	47.6	59.5	57.0	37.5	42.6	40.6	27.3	32.4	29.5

SUMMARY OF MAXIMUM, MINIMUM AND STANDARD AIR THERMOMETERS FOR 1899.

	Maximum.	Minimum.	Standard.		
			7 a. m	12 m.	6 p m.
	Ave.	Ave.	Ave.	Ave.	Ave.
January	30.5	13.7	19.3	25.3	25.3
February	27.1	13 6	18.2	24.9	23.4
March	37.5	23.2	28.5	33.4	31.7
April	56.8	36.3	42.3	52.9	52.0
May	68.7	46.4	52.6	63.6	62.5
June	82.3	56.6	66.4	77.2	75.3
July	82.9	59.5	67 6	78.7	77.9
August	83.9	59.2	67.3	80.1	77.2
September	71.1	50 0	56.3	65.4	62.7
October	63.8	42 9	47.6	59.5	57.0
November	45.4	32 3	37.5	42.6	40.6
December	38.5	21.5	27.3	32.4	29.5

READINGS OF MAXIMUM AND MINIMUM THERMOMETERS AT 7 A. M.

1899.	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.		JULY.		AUGUST.		SEPTEMBER		OCTOBER.		NOVEMBER.		DECEMBER.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	17.5	3	18	—1	49.5	20	38	26.5	80.5	58	82.5	63	78	50	80	56	89	65.5	50	35	47.5	37	54	36
2	11	1.5	13.5	1.5	35	20	34.5	24	87.5	58.5	85.5	61	88	57	87	63.5	75.5	64	45	33.5	46.5	30	55	37
3	24	9	27.5	10	34	27.5	34	23	82.5	48	73	52	94	59	89	64	72.5	62.5	47	26	39	27.5	48	35.5
4	41	23	27	18	46	32	39	25.5	59	38.5	76	55	97.5	71	87	64	92	55	52	30	47.5	30	39	30
5	59	35	25.5	15	43	33	41	26	66	36	88.5	65	93	68	90	68	68.5	47.5	72.5	42	47	35	32	19
6	37	21	27	10.5	53.5	18	40	24	73	43	93	63	88	63	78.5	57	84	58	65.5	47.5	45	34.5	27	18
7	34	14	23.5	10.5	38	25	50	29	73.5	43	91.6	66	75	58	81	51	70	41.5	63.5	35	46	33	27.5	13
8	22	6	21	11.5	30	18	46	28.5	72	48	90.5	70.5	81.5	64	75	53	81.5	54	60	35	55.5	34	39	13
9	36	4	11.5	—5.5	29.5	18.5	38	30.5	66	46	82	62	81.5	59	73	47	71	52.5	58	42	54	34	42	19
10	19	—2.5	0	—7	33	24	39	28	63	39	75.5	49	72.5	59	79	55	69	42	61.5	43.5	57	34	33	13
11	3.5	—3	0	—8	43	28.5	45	27.5	74	46	72.5	41.5	84.5	58.5	84	63	75	49	72	44	48	33	43	32
12	10	—4	5	—7	54	40	58	32	69	47.5	76.5	42	83.5	59.5	89.5	66	68	53	70	49.5	38	27	60	42
13	30	10	6.5	—4.5	63	29	65	37	72	53	84	63	81	56.5	91	62.5	72.5	50	71.5	51	32.5	27	56	35
14	38	26	10	1	29.5	23	57	42	73	37	89	63	72	55	77.5	56	61.5	40.5	78.5	53	34	25	47	25
15	49.5	35	18	5	34	24.5	70.5	36	61	32.5	90.5	67	83	54.5	73.5	44.5	57.5	38	86	58	37	28	38	21
16	42	32	34	15	41.5	28	55	33	59	39.5	84	50	84.5	64.5	80	47.5	66.5	40	67	53	50.5	36	26	15
17	46	35	37	21	31	14	50.5	29.5	55	42	66	52	84.5	66	85	52.5	79	49	79	53.5	42	27	30.5	17
18	38	15	44.5	32	32	14	55.5	37	63	47	76	47	82	58.5	91	58	87	59	73	54.5	48	32	38	27
19	17.5	8.5	45	32	42	27	75.5	44	60	44	82	58	79	59	92	60	84.5	61	66.5	49	60	44	47.5	30
20	33.5	8	45	30	28	15	69.5	49.5	50	45.5	83	57	70	50	97.5	65	74	56	63	41	54	37	49	20
21	38	19	52.5	36.5	24	13	66	39.5	51.5	45	86	53.5	79	60	97	65	59.5	49	48.5	33.5	39	28	45	28
22	45.5	29	47	36	32	18	58	40	56.5	43	73.5	49.5	91	60	95.5	66	67	48	45	26.5	48	28	46	27
23	33	21	47	31	44	30	71.5	43	61	42	79	60.5	75.5	52.5	78.5	62	69	43.5	50	30	50	33	48	28
24	41	21	31	16	36	25	65	43.5	68	41	93	60.5	83	56.5	71	61	62.5	47.5	63	45	43	33	43	30
25	41	23	27	16	30.5	20	67.5	47	74.5	47	88	62	84	66.5	83	63.5	70	60	81.5	48	37	33	41.5	18
26	29	19	34.5	17	33.5	22	73	51	76	50.5	82	54	83.5	68	88	61	75	48	79	49	43	33	25	6
27	47	10	44.5	29.5	32	24	69	44	79	56	80	51	89	65.5	87	65	50	39.5	76.5	49	39	33	20	10
28	10	1.5	36	20	36	18	76	47	74	54	85.5	59	82	58	69.5	56	59	41	55	47	43	37	33	14
29	24	3	......	......	39	25	74	44.5	69	53	86	51.5	86	58	82	57	70	47	65	48	43	31	34.5	10
30	12.5	2.5	......	......	30	21	82	57	84.5	59	75	52	88.5	55.5	83	62	52	38	56	39.5	48	36	18	0
31	16	—1	......	......	35	23	.....	.....	76.5	51.5	.....	.....	75.5	54	85	62	......	......	57.5	37	......	.....	7	—1
Average	30.5	13.7	27.1	13.6	37.5	23.2	56.8	36.3	68.7	46.4	82.3	56.6	82.9	59.5	83.9	59.2	71.1	50.0	63.8	42.9	45.4	32.3	38.5	21.5

AVERAGE MONTHLY TEMPERATURE FOR TEN YEARS.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1890	31.2	30.9	28.8	44.2	52.3	67.1	69.5	67.7	60.1	49.3	37.6	21.4
1891	25.9	28.3	30.8	45.3	52.0	66.4	66.4	68.5	66.2	48.8	38.4	35.5
1892	21.4	26.0	26.5	43.5	52.8	68.6	70.2	69.4	61.3	50.0	35.9	25.2
1893	15.5	20.6	29.5	41.1	54.1	68.2	69.8	68.8	58.0	52.0	38.2	27.5
1894	29.7	20.6	38.9	44.1	55.5	67.8	74.2	66.8	64.9	52.7	36.0	31.5
1895	21.8	16.9	26.9	44.4	59.0	†	†	71.2	61.7	45.4	39.6	31.4
1896	22.4	24.1	24.4	49.3	62.0	65.9	71.4	70.0	60.2	46.5	42.9	27.1
1897	23.2	26.1	33.8	45.1	55.4	62.4	73.5	67.6	62.4	52.6	39.7	29.2
1898	26.2	26.8	*	43.2	57.0	67.7	74.2	71.0	65.9	52.1	37.9	27.9
1899	22.1	20.4	30.4	46.6	57.6	69.5	71.2	71.6	60.6	53.4	38.9	30.0

* Maximum thermometer broken. † Record lost from June 13 to July 11.

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